ILLINOIS NATURAL HISTORY SURVEY

Reports

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No. 337

INSIDE

Introduced Crayfishes in Illinois

The practice of introducing non-native plants and animals into new areas for food production and sport and as pets has occurred commonly throughout human history. While many of these introductions go unnoticed or cause little harm to our natural resources, some cause severe problems for the native organisms that live in areas where introductions occur.

In Illinois, the introductions of aquatic species, such as the common carp, grass carp, and zebra mussel, have drastically affected our streams, rivers, and lakes. One of the newest threats to our native aquatic plants and animals are crayfishes. Field work conducted by Illinois Natural History Survey (INHS) biologists has documented that the rusty crayfish, a non-native species first collected from Illinois in 1973, has rapidly expanded its range in the state and that a second non-native species has recently become established in the state.

Current Illinois law prohibits the possession and sale of live rusty crayfish. Its strict enforcement represents the only means currently known to slow the spread of the rusty crayfish.

Crayfishes, also known as crawfish or crawdads, are found in almost all aquatic habitats in Illinois including lakes, creeks, rivers, and swamps. By feeding on plant material, insects, and snails, and by being a favorite food item for sportfishes, such as basses and sunfish, crayfish function as important members of aquatic food webs. The appetites of sportfishes for crayfishes have led to the introduction of non-native species. When fishermen use crayfishes as bait, they often dump unused crayfishes into lakes and rivers at the end of the day. This practice has most likely led to the establishment and rapid spread of the rusty crayfish (*Orconectes rusticus*) in Illinois. The rusty crayfish was first collected in Illinois in 1973 from the Illinois River at Peoria, and until 1985 was known from only nine locations. Since then the species has spread throughout the northern half of Illinois and can be found in almost all the major rivers in that part of the state. A field study conducted from June 1994 to October 1995 found the rusty crayfish at 39 sites in Illinois, 24 of which were in or near areas that receive intense recreational fishing pressure.

Photo by Christopher Taylor and Kevin Cummings, INHS Center for Biodiversity

A rusty crayfish, Orconectes rusticus, *from northern Illinois. The arrow points to the rusty-colored spots on the side of the crayfish, a feature that distinguishes this species from all other crayfishes in Illinois.*

Researchers at INHS and other institutions have documented the effects rusty crayfish have on aquatic ecosystems. The most dramatic effect is the displacement of native crayfish species. Prior to the appearance of rusty crayfish, the virile crayfish (*Orconectes virilis*) and the northern clearwater crayfish (*Orconectes propinquus*) occurred commonly in northern Illinois' lakes, creeks, and rivers.

Continued on back page

Wetland Restoration at the Middle Fork River Forest Preserve

Over the past several decades, dramatic losses in wetland acreage have occurred across the United States. More than half of the country's original wetland area has been lost, and over 200,000 more acres disappear each year. Illinois, in particular, has been devastated, losing more than 90% of its original wetland acres. This loss is of special concern because of the important functions that wetlands perform.

Many people now realize the value of wetlands in helping contain and disperse floodwaters, as illustrated by the 1993 flood along the Mississippi and Illinois rivers. Wetlands are also of great importance as habitat for plants and animals. In Illinois, more than 40% of the state's threatened and endangered species use wetland habitats. This increasing realization of the great importance of wetlands, combined with their dramatic recent losses, has led to the rapid development of the science of wetland creation and restoration.

In east-central Illinois, Survey researchers, in cooperation with the Champaign County Forest Preserve District, the Grand Prairie Friends, and The Nature Conservancy, have worked to restore a kettle marsh along the Middle Fork of the Vermilion River. Historically a wetland, this area had been drained by underground field tiles and had been previously used as pasture. In 1990, the drainage tile system was dismantled, restoring the natural hydrology. Almost immediately, wetland vegetation began to return, emerging from the existing seedbank, as well as establishing from nearby seed sources and from seeds brought in by wildlife. Forty-six species were recorded in the first year alone, dominated by native plants, such as spikerush, water plantain, beggar-ticks, and marsh yellow cress. Little vegetation was planted. Natural revegetation and community development were allowed to proceed at their own pace.

As documented by yearly vegetation sampling since 1991, wetland plants, such as duckweed, smartweed, sedge, and millet, established and flourished almost immediately, while others, like arrowhead and rice cutgrass, did not reach prevalence for a couple of years. Although rare at first, problematic, aggressive species, such as cattail and reed canary grass, became more dominant in the passing years. This growing and diverse wetland plant community encouraged the immigration of wildlife. Songbirds, shorebirds, rails, waterfowl, muskrats, coyotes, rabbits, deer, turtles, frogs, and snakes have all found this new wetland. Two birds listed as endangered in Illinois have been observed in the wetland, specifically the pied-billed grebe and the northern harrier (or marsh hawk). In 1994, a pied-billed grebe nested successfully in the marsh, producing several offspring.

Research, monitoring, and management of the wetland are continuing with the help of Illinois State Geological Survey researchers. In addition to continued vegetation sampling, water levels both above and beneath the ground are being monitored with staff gauges and groundwater

Continued on page 5

Photo by staff of INHS Center for Wildlife Ecology

INHS researchers sampling vegetation at the Middle Fork River Forest Preserve.

Human Monocytic Ehrlichiosis

Human monocytic ehrlichiosis, first recognized in 1987, is a disease characterized by fever, headache, malaise, myalgia, and nausea or vomiting. Most cases of this sometimes fatal disease have occurred in the Southeast and the Midwest usually in spring and early summer. The vector of the causative agent of the disease is thought to be the lone star tick, *Amblyomma americanum.*

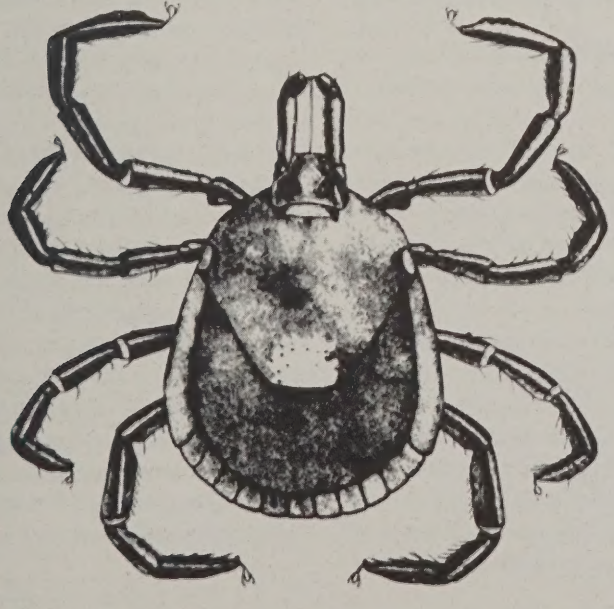
The disease was first thought to be caused by infection with *Ehrlichia canis,* a pathogenic organism found in dogs, but in 1991 the causative agent was found to be an unrecognized species of *Ehrlichia.* This organism was named *Ehrlichia chaffeenis* late in 1991. Five cases of human monocytic ehrlichiosis have been reported in Illinois. In 1994 a case was reported in Jackson County. To date in 1995, four cases have been reported, all in southern Illinois: one case in Alexander County, one case in Johnson County, and two cases in Perry County. The Johnson County case was fatal. The suspected vector, the lone star tick, is abundant in the southern third of Illinois, and it is of widespread but sporadic occurrence in the northern two-thirds of the state. Lone star tick populations are dependent upon white-tailed deer populations.

In spring 1992, microbiologist Jacqueline Dawson of the Centers for Disease Control and Prevention, Atlanta, Georgia; physician Jeffrey Nelson, an INHS affiliate from Rush Presbyterian St. Luke's Medical Center, Chicago; INHS mammalogist Edward Heske; and INHS entomologist John Bouseman initiated collaborative field studies of human ehrlichiosis in Illinois. Investigations were conducted in Monroe, Clark, Lee, and Winnebago counties. As a result of these studies the first seropositive (positive for Ehrlichiosis antibodies in blood serum) wildlife (raccoons) in Illinois were discovered in Lee County in 1992, and the first seropositive deer were discovered in Monroe County in 1992. Seropositive deer also were found in Winnebago County in 1993. The deer findings were reported in the Journal of Wildlife Diseases, vol. 30, no. 2 (April 1994), pp. 162-168.

Photo by John Bouseman, INHS Center for Economic Entomology

Jacqueline Dawson and Jeffrey Nelson conducting field studies of human ehrlichiosis in Illinois.

It appears that white-tailed deer serve as a reservoir for ticks infected with human ehrlichiosis and that they play an important role in the natural history of the disease in this country. Deer carrying Ehrlichia antibodies seem to be more prevalent in southerly latitudes and at low elevations that have milder climates. Deer may serve as sensitive markers of Ehrlichia's distribution. Further research will be needed to clarify this relationship.



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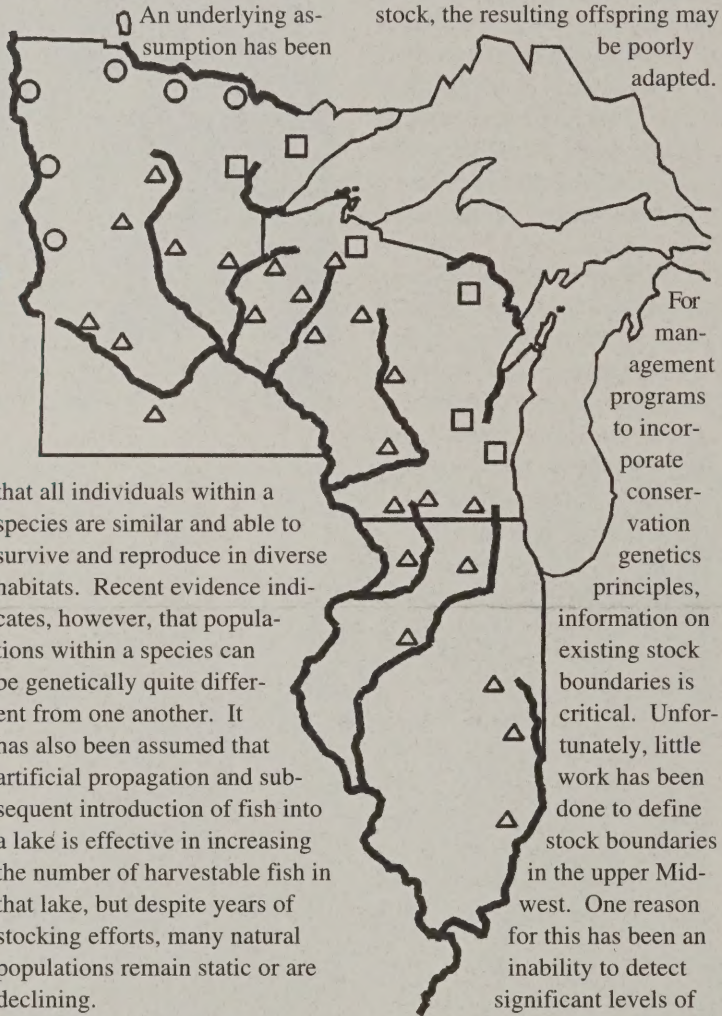
John K. Bouseman, Center for Economic Entomology, and Jeffrey A. Nelson, M.D., Rush Presbyterian St. Luke's Medical Center, Chicago, and an affiliate of the INHS Center for Economic Entomology.

Identification of Genetic Stocks in Midwest Game Fish

Since the turn of the century, transfer of fish from one lake to another has been a common practice among fisheries managers. An underlying assumption has been that all individuals within a species are similar and able to survive and reproduce in diverse habitats. Recent evidence indicates, however, that populations within a species can be genetically quite different from one another. It has also been assumed that artificial propagation and subsequent introduction of fish into a lake is effective in increasing the number of harvestable fish in that lake, but despite years of stocking efforts, many natural populations remain static or are declining.



Hypothetical sampling sites in the Mississippi, Great Lakes, and Hudson Bay drainage basins.

Population geneticists have shown that species often are composed of genetically distinct stocks. Each stock represents a group that has survived and evolved in isolation from other stocks. Unfortunately, many management programs have failed to acknowledge potential stock differences. As a result, individuals from one stock have often been transported and introduced into waters containing a different stock. Such stock mixing poses a significant genetic risk to native populations; when transplanted individuals survive and interbreed with the resident stock, the resulting offspring may be poorly adapted.

For management programs to incorporate conservation genetics principles, information on existing stock boundaries is critical. Unfortunately, little work has been done to define stock boundaries in the upper Midwest. One reason for this has been an inability to detect significant levels of genetic variation within a regional context. Newly developed molecular genetic techniques, however, now allow us to detect those levels of genetic variation.

Illinois Natural History Survey scientists and graduate students are working with biologists from the Wisconsin and Minnesota Departments of Natural Resources to study the population genetic structure of a number of fish species in the upper Midwest. Fifteen species with diverse life history traits and management priorities are being targeted. These include heavily managed game species, such as muskellunge and walleye, as well as nongame species, such as the johnny darter. The data generated will be used to determine if watershed boundaries correlate with the boundaries of genetic stocks. If patterns of stock structure are consistent among the diverse species studied, managers may be able to implement effective stock management for all species of concern and predict the most likely stock boundaries for species for which genetic data are unavailable.

The study area is of interest because of the proximity of three large drainage basins: the Mississippi River, Hudson Bay, and the Great Lakes. Where possible, three populations of each species were sampled from each of the major tributaries within each of these drainage basins. This sampling hierarchy allows scientists to determine the relatedness of populations within and among tributaries and, therefore, the limit of detectable genetic differences using the newest available techniques.

Genetic data obtained thus far (with proteins, mitochondrial DNA, and nuclear DNA) confirm the presence of distinct genetic stocks within the upper Midwest. In addition, results obtained for each of the diverse species studied are in general agreement. Stock boundaries generally conform to existing watersheds, although in some areas genetic stocks appear to correlate with older, postglacial watersheds.

Continued on next page

Genetic Stocks

continued from previous page

For example, populations in the upper Fox and upper Rock Rivers (Mississippi River basin) are genetically distinct from downstream populations located closer to the mainstem Mississippi River. Instead, they are genetically similar to populations from tributaries of Lake Michigan (Great Lakes basin). For management purposes, such results indicate that existing watersheds may form a starting point for the reduction of genetic risks associated with stock transfer, but additional information provided by this study will allow more precise identification of stock boundaries.

When the study is complete, recommendations for alterations to existing management practices (e.g., establishment of stock-based management units and geographical limits to transportation and introduction of fish) will be discussed with management biologists from all states involved. We hope that the information will be used to improve the efficacy of stocking where it is deemed necessary, and to protect the genetic integrity of our fisheries resources for long-term productivity.

Robert D. Fields and David P. Philipp, Center for Aquatic Ecology

Wetlands

continued from page 2

wells. Researchers are investigating the development of the plant community over time and hope to relate these changes to the hydrology of the wetland. Initial results indicate that certain plant species, such as beggar-ticks, spikerush, and ragweed, fluctuate dramatically between wet and dry years. Monitoring of potentially problematic, aggressive plant species is continuing and, when necessary, control measures are taken. In November 1994, a controlled burn was conducted in an effort to help control cattail and reed canary grass. In response to this action, plant species diversity increased sharply, to over 60 species. Unfortunately, both target species increased slightly, while two highly desirable species (arrowhead and water plantain) decreased greatly. Based on these conflicting results, the use of fire as a management tool to control problem vegetation in the wetland is still being studied.

Finally, taking the restoration process one step further, surrounding areas are being restored to native prairie and oak savanna habitats. This continuing process involves many aspects of vegetation establishment and management, including the seeding and planting of prairie species and the regular use of fire to control problem vegetation and encourage the growth of fire-adapted prairie and savanna species. Continued monitoring of the entire restoration will ultimately allow the effectiveness of various habitat management techniques to be evaluated. Although restoration and management are ongoing, the overall goal of this project is to develop a natural, functioning, wetland-centered ecosystem that contributes to the natural resources of Illinois. Researchers also hope to gain valuable knowledge about the science of restoration and apply it successfully to similar types of restoration and management projects in the future.

Photo by staff of INHS Center for Wildlife Ecology

A restored wetland at the Middle Fork River Forest Preserve.

Brian Wilm, Scott Simon, and Marilyn Morris, Center for Wildlife Ecology

Species Spotlight

Witch Hazel

Susan Post

As you walk in the woods during the fall and winter, you may discover a small tree with fragrant yellow blossoms. Your first thought might be that this plant has its seasons mixed up and "thinks" its spring. If you dust off your botany, though, you may recognize witch hazel, a small tree belonging to the plant family Hamamelidaceae and related to the sweet gum.

Photo by Ken Robertson, INHS Center for Biodiversity

Witch hazel blossom.

Illinois has one native species of witch hazel, *Hamamelis virginiana*, which grows in colonies in the understory of dry or moist woods. The plant seldom reaches more then 10 feet tall and can be identified by its scallop-margined leaves that turn brilliant yellow in the fall and are arranged alternatively on zigzagging branches. This allows each leaf maximum exposure to the sun filtering through its shady domain. The plant's blossoms appear after the leaves have fallen, forming yellow clusters along the branches. The flowers have four long strap-like petals, each an inch to an inch and a half long. These petals have the unique ability to curl up in a bud when the temperatures drop and unfurl in the warming sun. This adaptation protects the nectar and pollen for warmer days when insects will venture out again. Witch hazel flowers are followed by a hard, two-chambered seed capsule that ripens a year later.

Witch hazel is a plant with many common names, each related to a unique aspect of the plant. The generic name, Hamamelis, means "together with fruit," and refers to the fact that witch hazel is the only tree in the North American woods to have ripe fruit, flowers, and next year's leaf buds all on the branch at the same time. The name "snapping hazel" comes from the seedpods. As they dry and shrink, they will explode with an audible pop to scatter the seeds up to 30 feet from the parent. This mechanism for seed dispersal helps to eliminate overcrowding and increases the likelihood that this year's crop will have room to grow.

The tree has also been called water-witch. The word witch comes from an Anglo-Saxon word meaning "to bend." The forked springy branches of witch hazel were used by early settlers, and later dowsers, as divining rods to search and detect underground water and minerals.

Native Americans showed pioneers how to make extracts for use as eye washes, liniment, and to stop bleeding. Modern uses include an astringent made from the tannin-rich bark, twigs, and leaves to be used on insect bites, stings, sunburn, and as a soothing after-shave lotion. In the past, even the army has used branches of witch hazel for camouflage purposes.

As you take a walk in the woods seek out the witch hazel's yellow blossoms and popping seedpods as they bring a bit of a reprieve during those gray days of fall and winter.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Flower Forms

Objective: to learn some of the different arrangements of flower petals

Materials: multiple copies of **Flower Forms**

Vocabulary: corolla, petal, cross-pollination, pollen

Comments: Flowers are endlessly diverse and can be very simple or quite complex. These characteristics have long fascinated people and insects, but for different reasons. The arrangement and shape of the petals (corolla) of a flower help botanists identify the plant. The different petals also attract insects for the transfer of pollen from one flower to another. This process is called cross-pollination. In this edition of *The Naturalist's Apprentice*, we will investigate some of the different flower petal (corolla) arrangements by trying to match descriptions with flower drawings.

Procedure:

1. Introduce the subject of flowers with the material presented above and in *Species Spotlight*.

2. Distribute copies of **Flower Forms** and have students match the description in column 1 with the correct flower picture in column 2. *Answers: E, I, C, A, G, D, J, H, B, F*

3. Have students try to name an insect that would be likely to pollinate each flower type.

The Naturalist's Apprentice

Flower Forms

Michael Jeffords

Flower Forms

The arrangement of petals on a flower helps botanists identify a plant and also attracts insects to the flower to help the plant move pollen to other plants of the same species. This process is called cross-pollination. Read the flower descriptions in column 1 and find the flower type in column 2 that is closest to the description.

Column 1

petals surrounded by a small crown around the throat of the flower ____

cross-shaped flowers ____

funnel-shaped flowers ____

hoodlike or helmet-shaped ____

rays surrounding central disc ____

flat and wheel-like ____

flower with a pouch ____

a lone spur or tube at end of flower ____

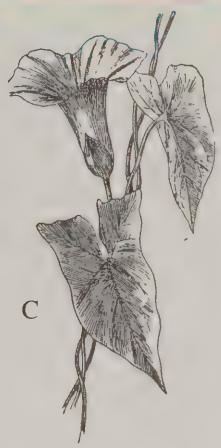
tubelike flower ____

bell- or cup-shaped ____

Column 2

A

B



C

D

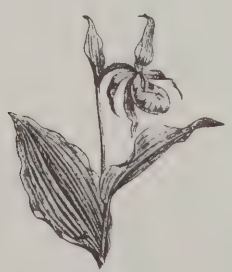
E

F

G

H

I



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Introduced Crayfishes

continued from front page

In areas where rusty crayfish are now found, both the virile and northern clearwater crayfish are either present in very small numbers or totally absent. The rusty crayfish is a large, aggressive species compared to other Illinois crayfishes and as such is able to force these other species out of habitats that provide refuge from predation. Deprived of these habitats, species such as the virile and northern clearwater crayfishes are either consumed by fish or mammal predators or are forced to move to other areas. Researchers outside of the Survey have shown that rusty crayfish can affect other members of the aquatic food chain by rapidly expanding their population sizes after moving into new habitats. These large populations can, over time, consume most of the aquatic vegetation used for refuge from predation by juvenile fishes.

In recent field work, INHS biologists discovered a population of a second non-native crayfish species in Illinois. The golden crayfish (*Orconectes luteus*), a species that occurs natively in central and southern Missouri, was first collected in Illinois in 1992. Subsequent work has shown that a reproducing population of the golden crayfish occurs in a restricted portion of Apple Creek in Greene County and that displacement of native species is not apparent. In an effort to determine if rusty crayfish are unique in their ability to outcompete native crayfishes, future work will focus on determining if the golden crayfish is able to displace other species.

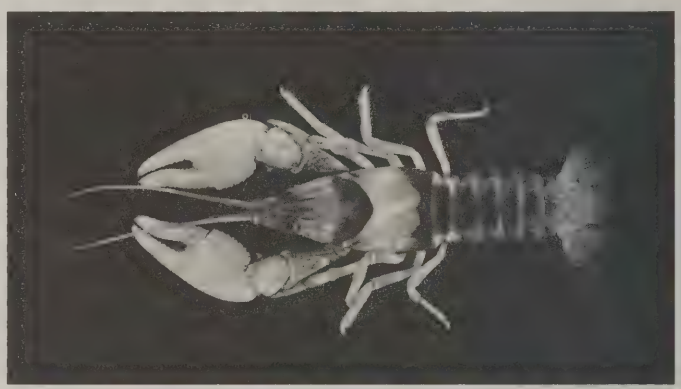

Photo by Christopher Taylor and Kevin Cummings, INHS Center for Biodiversity

The golden crayfish, Orconectes luteus, *a recent introduction into Illinois waters.*

Current Illinois law prohibits the possession and sale of live rusty crayfish. Its strict enforcement represents the only means currently known to slow the spread of the rusty crayfish. Native Illinois crayfishes, especially our rare and endangered species, can ill afford to be forced from native habitat by foreign invaders.

Christopher A. Taylor, Center for Biodiversity

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INSIDE

Children Conduct Biological Control Research

Photo by Lee Solter, INHS Center for Economic Entomology

Fourth graders weigh gypsy moth larvae to determine if microsporidian disease affects weight gain.

The gypsy moths *(Lymantria dispar)* that are found in the United States originated in Europe. They were brought to North America in 1868 by Leopold Trouvelot, an amateur entomologist and astronomer, who planned to use them to produce silk. The moths escaped from his house in Medford, Massachusetts, then multiplied and began killing trees. Today, gypsy moths are found mainly in the northeastern states but they can also be found in Michigan, Ohio, Virginia, and sometimes Illinois.

The favorite foods of gypsy moth larvae are the leaves of oak, willow, aspen, and birch, but they will eat the leaves of many other trees. Gypsy moths have become serious pests in the forests of North America. Pesticides can be used to decrease the gypsy moth populations but pesticides may kill other harmless insects. Some scientists are focusing on the use of natural predators and pathogens to decrease the populations of gypsy moths. Some entomologists are testing microsporidia, a protozoan pathogen group, as a weapon against the gypsy moth.

Our fourth grade class at Leal School in Urbana, IL, was invited to perform an experiment with one kind of microsporidium that was found in gypsy moths in Slovakia but does not occur in gypsy moths in North America. We agreed to help. First, we visited the laboratory to learn about what we would be doing. We were going to help with an experiment to study microsporidia. Each week, a group of three or four students went to the laboratory to perform part of the experiment.

For each of 7 trials, 10 gypsy moth larvae were fed microsporidian spores in 1 µl of water from a metal loop and 10 additional larvae were fed 1 µl of water without spores. We then weighed each larva by picking it up with forceps and placing it on a sensitive scale. We recorded the weights on data sheets and used a calculator to average the weights of the control larvae and the infected larvae. We learned that there should always be a control group in an experiment to compare with the infected group.

After weighing, we placed the larvae in plastic cups with food in them, one larva per cup. These were kept in growth chambers. The larvae were weighed again 7 and 14 days later. Forty-five days after treatment, the developmental stage of each insect was recorded and they were dissected to make sure that larvae fed spores were infected and larvae fed water were uninfected.

The difference between the average weights of the infected and control groups of larvae was insignificant at the beginning of the experiment. For six of the seven groups, the average ending weight of the infected larvae was

Continued on back page

Colleen Brodie and Shameem Rakha, teachers at Leal Elementary School in Urbana, IL, and Lee Solter, research scientist at the Illinois Natural History Survey, had several objectives for a research project for fourth graders:

- Conduct original research in a scientific laboratory
- Use the scientific method, including hypothesis testing and controlled experimentation
- Practically apply mathematics and data analysis
- Publish results in a scientific newsletter
- Integrate project into classroom curriculum

Land Managed for Waterfowl in the Illinois and Mississippi River Floodplains

Illinois is an important migration area for waterfowl in the Mississippi Flyway, with some 22 species of waterfowl passing through the state each spring and fall. From 1955 to 1992, the flyway supported an average of 36 percent of all ducks in the contiguous United States during the midwinter waterfowl surveys. A majority of mallards in the U.S. uses the flyway and stays an average of 28 days on traditional fall migration areas in Illinois, displaying an area of activity around each migration area of approximately 30 miles. Consequently, waterfowl refuges used by migrating birds should be about 50 miles apart in areas where habitat is continuous so that rest areas are within their daily flight range. If rest areas or food are scarce, ducks will stay only a day or two before continuing their migration, usually flying at least 100 miles between stops.

Photo by Larry Brooks, Peoria Journal Star

Waterfowl over Lake Chautauqua.

This study investigated the acreage of public and private land managed for waterfowl with water level control capabilities for moist-soil or other food production in the floodplain of the Illinois River and the floodplain of the Mississippi River, including Illinois, Missouri, and Iowa from St. Louis northward to the Illinois-Wisconsin border. These two floodplains were selected because they include the Upper Mississippi River Environmental Management Program's Habitat Rehabilitation and Enhancement Projects and because of the long tradition of private duck clubs in the Illinois Valley.

The primary objective of moist-soil management is to mimic the natural water regime and lower water levels during summer to expose mudflats through drawdown. Historically, water levels typically receded in the summer months in the Illinois Valley, exposing mudflats. In autumn, water levels would increase, inundating the mudflats and the sources of food provided by moist-soil plants.

Moist-soil plants that germinate on these exposed soils provide the primary source of natural food for waterfowl migrating through Illinois. Water levels must remain low for at least 70 days to allow moist-soil plants time to mature and produce seeds and tubers; optimum seed production usually occurs when moist-soil plants are not inundated for 90 days. By controlling the frequency, timing, length, and depth of water level manipulations, the necessary habitat resources for waterfowl can be produced at times that coincide with migration and other critical events in their annual cycle.

In the late 1930s, some duck clubs in the Illinois River valley began to use moist-soil management as a way to attract ducks to their property. Moist-soil management continues to be one of the most effective and beneficial waterfowl management techniques for improving habitat for migratory waterfowl on public and private lands in Illinois. Over 80 percent of the national wildlife refuges in the United States practice moist-soil management. When compared with waste grain from agricultural fields, such as corn, moist-soil plants may provide waterfowl with lower levels of metabolizable energy, but they contain a better balance of nutrients.

Potentially, there are about 31,000 acres of mudflats and natural moist-soil plants in the Illinois River floodplain. However, because of fluctuating water levels, usually only 7-45 percent of them are available each year.

From questionnaires we circulated to public area managers and private duck clubs concerning their management practices, the responses indicated that of the 110,000 total acres in the Illinois River floodplain on public areas and private duck clubs, there were about 25,000 acres reported as having some water management capabilities for waterfowl, or approximately 23 percent of the public and private duck club

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Indiana Bats in Illinois

Bats are a greatly misunderstood, feared, and persecuted group of animals. This is unfortunate because scientists have been discovering that bats play vital roles in the ecosystems in which they occur and are beneficial to humans in several ways. For example, most North American bats are insectivorous and consume vast quantities of night-flying insects, including mosquitoes and crop pests.

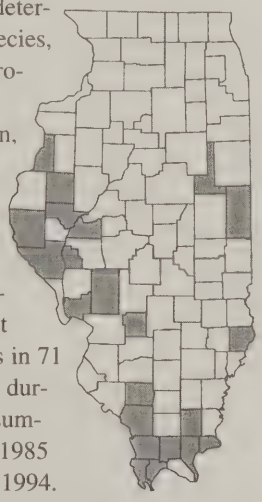
Twelve species of bats occur in Illinois, four of which are listed as endangered by the Illinois Endangered Species Protection Board. Two of these species, the Indiana bat (*Myotis sodalis*) and the gray bat (*Myotis grisescens*), are also federally endangered. The Indiana bat was one of the first species listed as endangered by the U.S. Fish and Wildlife Service; the total population of this species (determined by censusing hibernating bats) had declined 28 percent from 1960 to 1975. Indiana bats are associated with the major cavernous limestone (karst) regions of the midwestern and eastern United States. During the winter, they congregate in caves and abandoned mines to hibernate in tightly-packed clusters of up to 300 bats per square foot. The main hibernation sites (hibernacula) for this species are located in southern Indiana, Kentucky, and Missouri. Indiana bats leave their hibernacula in April and the species is more widely dispersed during the summer. Until recently very little was known about the summer distribution or habitat requirements of Indiana bats. The first maternity colony (reproductively active females and their young) was not located until 1971 when its roost tree (a dead American elm *[Ulmus americana]*) in Indiana was bulldozed. The discovery of this tree and two trees subsequently used by the colony indicated that Indiana bats roost beneath slabs of loose, peeling bark on dead trees or certain live hickories.

Most historical records of Indiana bats from Illinois were of hibernating or migrating individuals. Prior to 1985 there were summer records of reproductively active females or juveniles from only Jackson, Pike, Union, and Wabash/Edwards counties. In 1985 James Gardner and this author, both from the Illinois Natural History Survey, and James Garner from the Illinois Department of Conservation (now Department of Natural Resources) began a statewide study of the summer distribution and habitat of the Indiana bat. Their work was made possible through the cooperation of the Illinois Department of Transportation, Shawnee National Forest, U.S. Fish and Wildlife Service, and Indiana/Gray Bat Recovery Team.

Information on Indiana bat distribution was obtained by mist netting above streams and rivers. Bats use these watercourses as flyways, foraging areas, or sources of drinking water. A pair of metal poles either 6.1 or 9.2 m tall is positioned under overhanging tree branches on opposite sides of the stream channel. Two to four very fine mist nets are stacked vertically and suspended above the stream between pulley ropes attached to the poles. Using this system, it is possible to raise the top of the uppermost net to the canopy and create a wall of net that blocks most or all of the flyway above the stream. The nets are raised at dusk and checked every 10 to 15 minutes until midnight or 1:00 a.m. Bats that become tangled in the net are carefully removed and examined to determine species, sex, reproductive condition, and weight.

Photo courtesy James Gardner

Bat with radio transmitter.



Map indicates Illinois counties in which the Indiana bat has been observed from 1985 to 1994.

Mist netting was conducted at 191 sites in 71 counties during the summers of 1985 through 1994. Indiana bats were captured at 35 sites in 21 counties in the southern two-thirds of the state. Several caves also were investigated during the summer and adult male Indiana bats were found roosting in two caves and one

Continued on back page

Effects of Electrofishing on Sunfish

There are a number of ways to collect fish for management and research. Everyone knows about hook-and-line fishing and some are familiar with a seine (a net used to herd fish). Researchers also use various trap nets (i.e., slat traps) to capture different types of fish. Few methods, however, are as useful and effective as electrofishing. Many fisheries management research projects require the collection of a relatively large number of fish. With electrofishing, large numbers can be acquired with minimal effort.

Electrofishing boats are used on large lakes and rivers. They usually consist of a 16-foot flat-bottom boat with two booms extended forward from the bow that allow up to six electrodes to hang in the water (see photograph). The electrodes used to stun the fish are connected to a generator in the boat. The crew consists of two or three people. One person drives the boat close to the shoreline and the other(s) stands on the bow and uses large dip nets to collect the fish. When the fish are shocked they usually float to the surface, allowing for easy identification and retrieval. Once collected, the fish are placed into a live well in the boat and remain there until they are worked-up (measured, weighed, etc.) and returned to the water.

Photo from INHS photo archives

A boat outfitted with electroshock unit being used by INHS researchers.

Electrofishing streams usually requires the use of a backpack shocker to sample the fish in the same manner. With this method, one person wears a backpack that has been equipped with a battery power pack and walks through the water while wearing chest waders. In one hand is the cathode and in the other is the anode, both of which direct the current into the water. One or two others walk near the person with the backpack and collect the fish.

When we sample a fish population we collect only a small percentage of the total population of any given species. From this relatively small sample we are able to infer characteristics about a population or community. Electrofishing can have negative effects on fish in certain situations. Studies indicate that of the fish collected, a small percentage may suffer some form of injury or even death. The rate at which this occurs varies from species to species with the salmonids (trout in particular) being the most susceptible. Fish common to Illinois waters (e.g., largemouth bass and bluegill) have been shown to have low incidents of injury or mortality as a result of electrofishing. These injuries are for fish collected from a percentage of the population, not the entire population; thus, any mortalities or injuries do not have a large impact on the population as a whole.

Our research on the effects of electrofishing on bluegill was an attempt to measure any indirect effects on bluegill feeding rates or susceptibility to predation. We are asking, "What happens to the fish that are not collected either because they got away or because they were not the target species?" If there is any extensive long-term depression of feeding in shocked groups of bluegill, there may be consequences in terms of size, reproduction, or condition of the bluegill. Also, if shocked bluegill can be caught by a feeding largemouth bass, we might see a reduction in bluegill population size. Either one of these negative effects would lead to the conclusion that electrofishing may have harmful effects.

The results of our research indicate that bluegill (small and large sizes) have reduced feeding for up to five hours after shocking. This may sound alarming to anglers, but biologically this has relatively little impact on the individual fish and absolutely no impact on the bluegill population. Small bluegill are more likely to be eaten by largemouth bass predators immediately after the shocking experience than unshocked bluegill. In our laboratory experiments, which were performed in an eight-foot diameter pool, the foraging largemouth bass would immediately eat any shocked bluegill that moved (either by gilling or twitching). This increase in the chance of being eaten by a large-

Continued on next page

Electrofishing

continued from previous page

mouth bass when the bluegill was shocked decreased with time. After 10 minutes, the shocked bluegill recovered enough from the experience to behave like their unshocked counterparts. These results represent the maximum potential effects of electrofishing. The pool used had ideal lighting conditions, no habitat complexity (no aquatic plants, woody debris, or submerged trees), and good foraging contrast (the interior of the pool was painted white); therefore, it was easy for the largemouth bass to see a shocked fish. In a real lake or pond this simplistic environment will not be present. Lakes will have varying degrees of turbidity, habitat complexity, and will not be painted white! This means that our results are most likely the "worst-case scenario" for the effects of electrofishing in lakes and ponds.

The impetus for our research was the growing concern, among researchers and the public, about the potential negative effects of electrofishing on fish. Are we hurting the fish that we are trying to understand and help? Our research indicates that the effects of electrofishing on bluegill feeding rates and susceptibility to predation are negligible. Fish that are sampled with electroshock will not have any long-term negative effects on their feeding or vulnerability to predation due to the shocking experience. Electrofishing is not completely harmless to the fish—there are occasional injuries and even death—and there may be very short-term effects on behavior, feeding, or susceptibility to predation. However, the knowledge acquired with the help of electrofishing surely outweighs these negligible short-term effects.

Sean Callahan, Center for Aquatic Ecology

Waterfowl

continued from page 2

land. This leaves around 85,000 acres (77%) of the total public and private duck club land available to the river without any influences from low levees or other structures associated with waterfowl management. Additionally, much of the 25,000 acres of land with water control capabilities used for waterfowl management is available to the river near bankfull conditions. As a result, most of the public and private waterfowl land is available to the river under high water conditions.

Overall, public and private duck club lands with water management capabilities in the Illinois River floodplain represented less than 6 percent of the total 426,000 acres in the floodplain or about 10 percent of the acres in the nonleveed floodplain. We should note that 187,000 acres (44 percent of the floodplain) have been protected in levee and drainage districts for agriculture.

In the Mississippi River floodplain in Illinois, Iowa, and Missouri from Pool 12 (Wisconsin-Illinois border) through Pool 26 near St. Louis, about 617,000 acres (57 percent in the 1.1 million acres of the floodplain) are devoted to agriculture. We found that wetland and deepwater habitats occupied 227,000 acres of the state and federal public areas, or about 21 percent of the floodplain. On these public areas, there were approximately 32,400 acres with water control capabilities for use in waterfowl management, which represented about 14 percent of all the public land in this segment of the floodplain. Consequently, approximately 195,000 acres, or 86 percent, of the public lands in the floodplain from St. Louis to the Wisconsin-Illinois border were accessible by the river and not managed with water control capabilities for waterfowl. We also found that virtually no acres of private duck clubs with water management capabilities occurred outside of levees constructed for other purposes in this stretch of the Mississippi River.

The small percentages of public and private lands managed for waterfowl in these segments of the Illinois and Mississippi river floodplains are (1) providing important midmigrational habitat during fall and spring to migrating waterfowl in the Mississippi Flyway where we have lost approximately 90 percent of our presettlement wetlands; (2) hosting a multitude of plant, game, and nongame species, as well as threatened and endangered species throughout most of the year; and (3) protecting riverine habitat from agricultural and other types of development.

Photo by Michelle Georgi, INHS Center for Wildlife Ecology

Mallards feeding on moist soil plant seeds.

Stephen P. Havera, Aaron P. Yetter, Christopher S. Hine, and Michelle M. Georgi, Center for Wildlife Ecology

Species Spotlight

Beavers

Thomas Rice

One of the animal kingdom's most versatile members is a skilled engineer, a tireless lumberjack, and an excellent swimmer; it is also Illinois' largest rodent — the beaver, *Castor canadensis*.

Beavers are noted for their construction of dams, which can be deemed a marvel or a nuisance, depending on the location. Beaver dams can flood pastures and roads and destroy timber and trout streams. On the positive side, beaver dams reduce erosion, and the ponds they form can create a habitat for many forms of life: insects lay eggs in them, fish feed on the insect larvae, and many kinds of birds and mammals come to feed and drink.

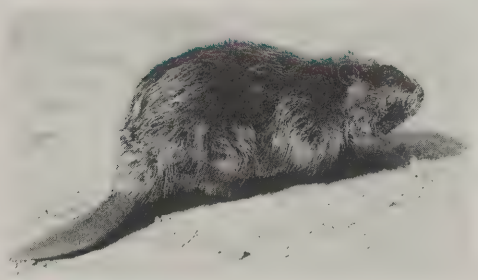


Photo courtesy New York Zoological Society

The beaver. Castor canadensis.

Near the dams can be found the beaver's lodge, with its living quarters and underwater entrances. These lodges are shared by beaver families. Beavers also live in burrows in the banks of lakes or streams.

Beavers mate for life, and their offspring (one to six kits in a litter) will stay with the parents for two years and then go out on their own. Quite a crowd can inhabit a beaver lodge as the parents and as many as a dozen offspring share the lodge in winter and feed from a carefully stored food cache.

Primarily a nocturnal animal, the beaver labors from dusk to dawn on its latest engineering project along a river or stream. The beaver has small eyes, stubby ears, and a stout body. Adults usually weigh from about 25 to 55 pounds. The beaver's coat is dark brown, and its feet and paddlelike tail are black. For protection from chilly water in winter, the beaver has an insulating thick layer of fat beneath its skin.

Beavers build their dams with a foundation of mud and stones, topped by brush and felled branches. Mud and soggy vegetation are used as a plaster to keep it all together. Beavers also dredge canals for easier transportation of dam construction materials. Beavers busily swim about transporting their building materials, including parts of trees they have gnawed with their huge incisors into convenient sizes. The beaver may decide to take a branch with its forefeet and rotate it, chewing off the bark for a snack, much like a human nibbles on an ear of corn. Twigs, leaves, and the bark of trees make up the bulk of a beaver's diet. Water lilies are a special treat.

As it builds a dam, the beaver swims with its webbed hindfeet while its tail serves as a rudder and its forefeet are held close to the chest, free to help hold objects against the chest or to push aside debris. Although the beaver is a graceful, seemingly at-ease worker in water, it will slap the water with its tail when an enemy is spotted and then quickly dive for refuge. On land it is a slow-moving worrier that often interrupts its activities to sniff the air and look for signs of danger.

Because of its valuable pelt, the beaver was trapped almost to the point of extinction in Illinois and other states by the late 1800s. Today's beaver population in Illinois is probably transplanted or emigrated from nearby states. Beavers can be found throughout Illinois and are abundant in many places.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

What's A Beaver To Do?

Objective: to learn about some of the diverse activities that make up a beaver's behavior

Materials: multiple copies of **What's A Beaver To Do?**

Vocabulary: behavior, consumers, producers

Comments: Animals are animals because they move around, explore, and manipulate their environment. We call these activities behavior. Why do they do this? The answer is simple: animals are not producers (like green plants), they are consumers. They cannot make their own food, so they must search out and ingest energy sources (food) to survive and reproduce. Animals literally glean a living from the environment. While the numbers and kinds of animals are enormous, their behaviors limitless, we can begin to understand how animals operate if we choose a single example, in this case the beaver, and look at the range of activities a beaver may pursue during its lifetime.

Procedure:

1. Introduce the subject of animal behavior with the material presented above and in *Species Spotlight*.

2. Distribute copies of **What's A Beaver To Do?** and have students circle the behaviors found within the beaver drawing that they believe are associated with beavers. The correct answers are all but the following: *eats other animals, active during day, always busy, hibernates, breeds several times a year.*

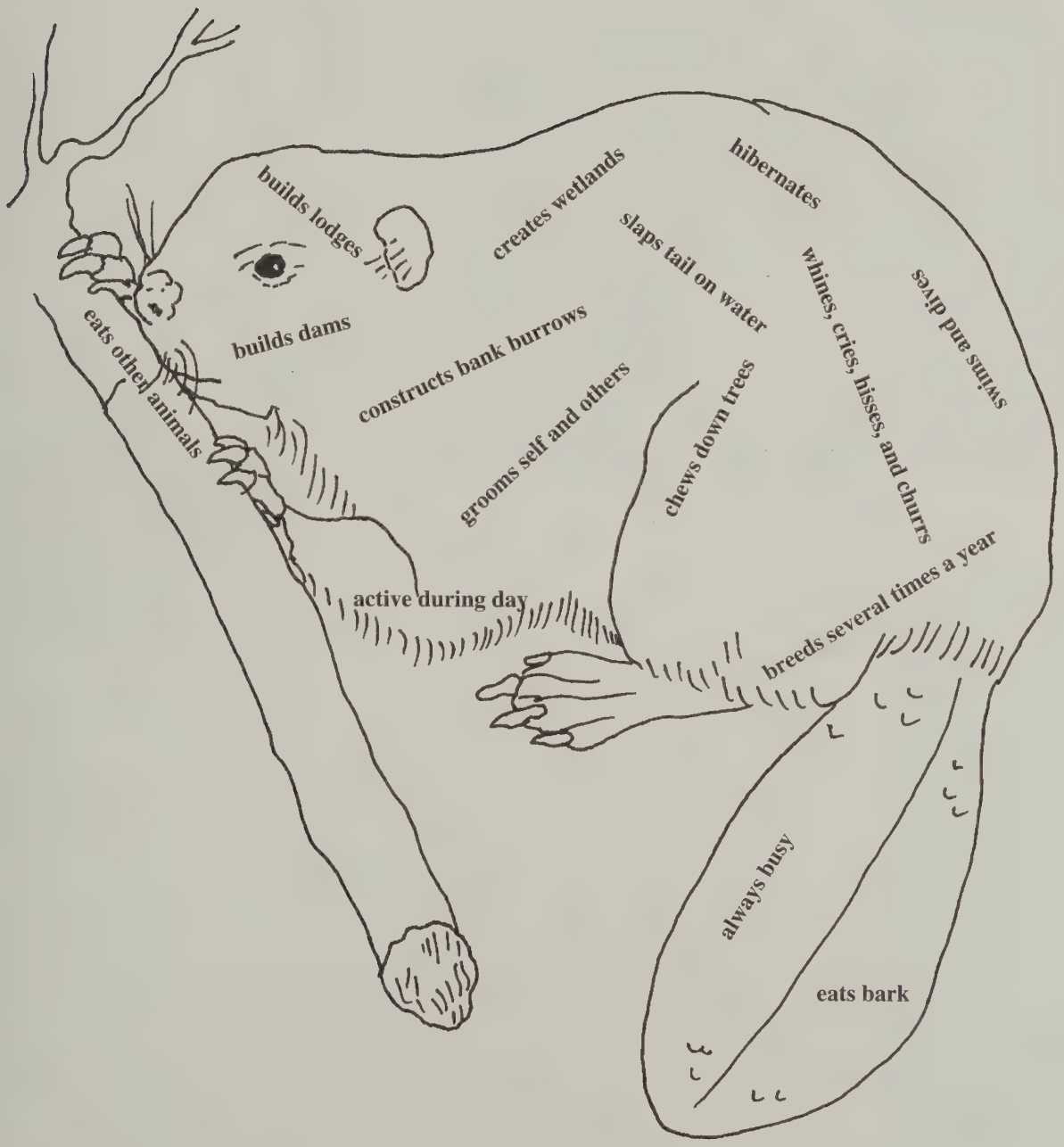
3. Have groups of students choose another animal, research its behavior, and repeat the exercise.

What's a Beaver To Do?

Michael Jeffords

What's A Beaver To Do?

Animals have a large number of activities that they regularly do to survive and reproduce. These activities are called behaviors. On the drawing below, circle the behaviors you think are associated with a beaver.



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RESOURCES

Bats

continued from page 3

Photo courtesy James Gardner

Roosting Indiana bat.

mine, including one in an additional county. Thus, there are now summer records for 22 Illinois counties, but none farther north than Henderson and Ford. Captures of reproductively active females and/or juveniles at 24 sites indicated that maternity colonies occurred in 16 of these counties.

A tree used by an Indiana bat maternity colony in Illinois was first discovered in Pike County in 1987 after hundreds of trees at numerous sites had been checked with a bat detector (which picks up bats' ultrasonic vocalizations). The availability of miniature radio transmitters (weighing 0.75 g) made it possible to track Indiana bats that had been captured in mist nets to their daytime roosts. A transmitter was glued to the back of a bat with medical skin glue, which held for about 10 days. During the day researchers with receivers and hand-held antennas homed in on the signals from the radio-tagged bats. In this way, 36 trees used by adult females and/or juveniles and an additional 15 trees used by adult males were identified. In most cases these were dead trees and the bats roosted beneath exfoliating bark; other roost sites were beneath the bark of live trees and within cavities in dead trees. Indiana bat roost trees were located in both upland and floodplain forests, typically within 500 m of a perennial or intermittent stream.

The tree species most frequently used by maternity colonies were northern red oak (*Quercus rubra*), slippery elm (*Ulmus rubra*), cottonwood (*Populus deltoides*), silver maple (*Acer saccharinum*), and shagbark hickory (*Carya ovata*). The mean dbh (diameter at breast height) of roost trees used by adult females and/or juveniles was 41.7 cm. Indiana bats were found to display loyalty to their summer ranges, and some roost trees were used for more than one year (although not necessarily by the same individuals). A roost tree has a limited "lifespan," however, because eventually all the bark will slough off or the tree will fall. Therefore, to be suitable roosting habitat, a forest needs to provide a continual supply of dead trees. Site and roost loyalty underscore the importance of preserving traditional habitat for this species.

Similar studies have since been conducted in other states, including Missouri and Indiana. The critically needed information acquired through these studies is being used to produce a revised recovery plan for the Indiana bat and should help with the protection of important summer habitat for this endangered species.

Joyce Hofmann, Center for Biodiversity

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Children Scientists

continued from front page

less than that of the controls. We also found that more individuals in the control group went to the stage of pupa than did the infected insects. This was true in all but two groups in which the larvae, both infected and controls, all made it to the pupal stage. Of the 140 larvae that started the experiment, 4 died. Each of the four were a part of the infected group. Three larvae were killed by the use of forceps.

From this experiment, we conclude that the microsporidium slightly decreased the growth rate of gypsy moth larvae that were fed spores. In order to find out more about the effects of microsporidia on the growth of gypsy moths, we should do other experiments. We might want to change the timing of infection by feeding younger larvae or the amount of microsporidian spores fed to each of the larvae.

This article was written by the following Leal School students:

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ILLINOIS NATURAL HISTORY SURVEY

Reports

May/
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No. 339

INSIDE

Illinois River Fish Communities: 1960s Vs. 1990s

Though the Illinois River is a unique biological and recreational resource in Illinois, it is typical among large midwestern rivers in the way that its natural river-floodplain habitats have been degraded over the past century. Sources of stress have included draining and leveeing of floodplain wetlands for agriculture, pollution from treated and untreated sewage and industrial wastes, excessive siltation, overharvesting of aquatic resources, and manipulation of water levels to maintain a commercial navigation channel. By the 1950s, although a certain degree of pollution control had been in place for decades, Illinois River fish communities reflected a degraded system.

In 1957, the Illinois Natural History Survey began an annual fish population monitoring program of the entire Illinois River that continues to be updated yearly. Fish populations, monitored in this program, are sampled by electrofishing. A major goal of this program is to analyze the long-term data to separate and identify real trends from short-term variability. To simplify data summaries, three river segments are recognized based on similarities in fish communities and the amount of aquatic habitat per unit length of the river: the lower river (80 miles in length beginning at the Mississippi River); the middle (151 miles); and the upper (50 miles), including a section of the Des Plaines River near where it joins with the Kankakee River (see map) to form the Illinois.

Rather than considering all species collected, many of which were taken in small numbers, analysis of fish communities was further simplified by listing fish species in descending order of abundance for each river segment until 95 percent of the total catch was accounted for. Because the common carp (*Cyprinus carpio*) is more tolerant of degraded conditions than the bluegill (*Lepomis macrochirus*), these species were used as biological indicators to track the long-term environmental state of the river. In general and risking oversimplification, high catches of carp and few bluegill are expected in a degraded system; the converse may be the case in a healthy system. With better habitat conditions and a more diverse fish community,

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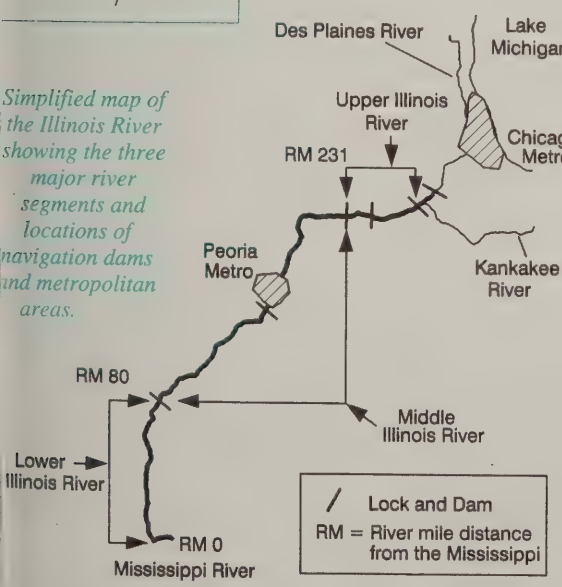
Photo by LTRMP staff at Havana

*Flathead catfish (*Pylodictis olivaris*) held by INHS researcher Thad Cook.*



Simplified map of the Illinois River showing the three major river segments and locations of navigation dams and metropolitan areas.

Rootworm Problems in First-year Corn, an Update

Western and northern corn rootworms are the most serious insect pests of corn grown after corn in the Midwest. Both species have a single generation per year. The adult beetles are present in cornfields from July through frost. They feed on corn pollen, silks, immature kernels, and foliage. From late July through September, egg laying occurs primarily in cornfields; few eggs are normally laid in other crops. The eggs remain in the soil until the following spring, when egg hatching begins in late May and early June. The larvae can survive only on the roots of corn and on the roots of a limited number of grasses. This larval feeding may reduce the amount of water and nutrients supplied to the developing corn plants. Extensive root damage makes plants more susceptible to lodging (plant leaning over or elbow). Larval feeding may also facilitate infection by root and stalk rot fungi, resulting in further damage. Yield losses also result from difficulty in harvesting lodged corn.

Photo by Eli Levine, INHS Center for Economic Entomology

Greenhouse cage containing western corn rootworm beetles and mature corn and soybean plants.

For many years, the practice of growing corn in rotation with soybeans, wheat, oats, or alfalfa provided excellent control of corn rootworms because their eggs are laid almost exclusively in cornfields, and larvae must feed on corn roots the following season to complete their life cycle. Unfortunately, western corn rootworm injury to first-year corn following soybeans has been increasing in severity for several years in east-central Illinois. Use of pyrethroid insecticides, primarily permethrin for corn earworm control in seed corn production fields, was initially suspected in the early outbreaks of 1987-1992. It was thought that these insecticides repelled adult western corn rootworm beetles from treated seed cornfields to nearby soybean fields where they laid their eggs. In 1993, 1994, and especially in 1995, the problems became increasingly more frequent and severe and included many fields of commercial corn that were not near cornfields treated with pyrethroid insecticides the preceding year.

Rootworm larvae collected in four east-central Illinois damaged cornfields in July 1995 and reared to the adult stage were all the western species, as were all beetles captured with emergence cages placed in two affected fields. Eggs from female western corn rootworm beetles captured in problem areas have not shown evidence of the prolonged diapause trait, that is, eggs hatch in a normal fashion after a single winter. Soil samples taken in October 1995 from three soybean fields that were adjacent to injured cornfields revealed that significant western corn rootworm egg laying was taking place. No viable eggs were present in earlier soil samples taken in mid-July. This confirms our belief that the problem is being caused by eggs that are laid in soybean fields rather than eggs that prolong their diapause for more than one winter.

Large cage studies with western corn rootworm beetles from problem fields in Saunemin, Illinois, and beetles from nonproblem areas in Mead, Nebraska, were conducted in a greenhouse during the summer of 1995. The beetles from Mead were used because of the heavy concentration of continuous corn in that area. If differences in egg-laying behavior were to be evident, we reasoned that these two population extremes would be good choices for this test. When given a choice between mature corn and soybean plants, western corn rootworm beetles from Illinois laid a significantly greater percentage of their eggs in the soil of the soybean plants than beetles from Nebraska.

We believe that because of the intense crop rotation in east-central Illinois, corn producers may have selected inadvertently for a strain of western corn rootworm that lays eggs in soybean fields. To date, all evidence suggests that some western corn rootworm adults are laying eggs in certain

Continued on page 5

The Decline of Freshwater Mussels in Illinois

Most Illinoisans are familiar with such endangered species as bald eagles, bobcats, or river otters, but they are probably not as familiar with less "charismatic" endangered species like salamanders, dragonflies, crayfishes, or mussels. Also, many people are aware that certain types of ecosystems— tallgrass prairie, oak savanna, or wetlands like bogs or fens—are disappearing. While these are important ecosystems that certainly should receive protection, INHS scientists and others across North America have found that aquatic ecosystems, particularly streams, continue to be degraded and are in need of stronger conservation measures.

The decline in aquatic organisms is much greater than that documented for terrestrial species and attests to both the magnitude of the problem and the inadequacy of water protection measures in Illinois and across the United States. Over 22 percent of the threatened and endangered species in Illinois are associated with aquatic habitats, including more than 67 percent of all state-listed animals.

The Illinois Natural Areas Inventory and Illinois Nature Preserves system have been highly successful in identifying and protecting representative examples of nearly all major terrestrial habitat types and communities in Illinois. As of August 1995, 236 sites totaling over 30,350 acres have been dedicated as Illinois Nature Preserves. These dedicated lands provide habitat for many rare terrestrial species. However, only one stream segment has been designated as an Illinois Nature Preserve, and less than 6 percent of all known occurrences of threatened or endangered aquatic species in Illinois occur within waters flowing through Illinois Nature Preserves.

The plight of freshwater mussels is a prime example of the decline of aquatic habitats and the species that inhabit them. North America has the most diverse freshwater mussel fauna in the world. Nearly 300 species of mussels are known from the U.S., and over 90 percent of these are found east of the Rocky Mountains. Recent stream surveys throughout the U.S. have documented drastic declines in mussel populations; indeed, mussels may be the most endangered group of animals in North America.

Through examination of over 61,000 specimens in mollusk collections in museums across the U.S. and by compiling data from scientific literature, INHS biologists have documented that 80 species of mussels were once present in Illinois waters. The streams of Illinois have been severely affected by pollution and siltation, and since 1970, only 59 mussel species have been found in the state. Eleven of the remaining 59 species are now known from a single river system or population. There is some evidence that some of these endangered mussels may not be reproducing and could be lost by the end of the century.

A grant to INHS biologists Kevin Cummings and Christine Mayer from money donated to the Wildlife Preservation Checkoff Program of the Illinois Department of Natural Resources (DNR) is providing funds to help determine the status of the clubshell (*Pleurobema clava*). This mussel, which was listed as a federally endangered species on 22 January 1993, now occurs in only a few streams in the Midwest. In Illinois the clubshell was once a common species in the Vermilion and Wabash rivers. A review of specimens collected as part of a survey conducted on the Vermilion River by INHS biologists in 1980 suggested that this species may still occur in the North Fork of the Vermilion River in Vermilion County. A preliminary search was conducted last summer with the help of DNR Natural Heritage biologist Bob Szafoni. Although no living clubshells were found, a few valves in relatively good condition provided hope of finding it when we return this summer. The results of the search were not all negative because we verified the presence of four other Illinois endangered mussels living in the river.

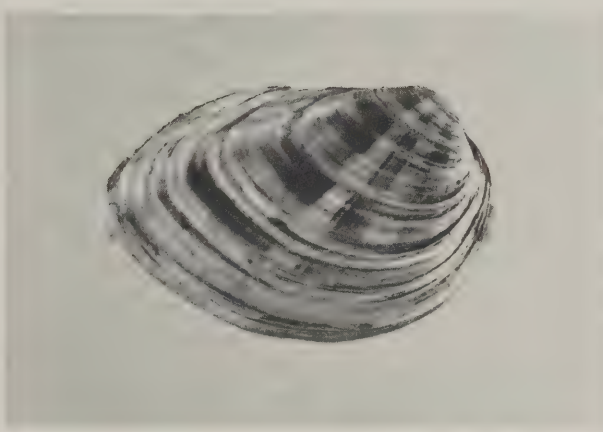


Photo by Kevin Cummings, INHS Center for Biodiversity

*Clubshell (*Pleurobema clava*) from the Tippecanoe River in Fulton County, Indiana.*

Kevin Cummings and Christine Mayer, Center for Biodiversity

Back to the Future: New Soybean Varieties From Old Sources

As abundant and widespread as soybeans are throughout Illinois and neighboring midwestern states, one might be led to believe that it is a crop native to this region. In fact, this couldn't be further from the truth. The true origin of soybean as a cultivated crop dates back over 3,000 years to barely recognizable types growing wild in China. Once domesticated into a manageable crop, the soybean was used by peoples of eastern Asia as a source of food, for medicinal purposes, and for animal feed for thousands of years prior to its introduction into North America. Soybeans were first grown in Illinois by John H. Lea in Alton in 1851.

The recognition of the potential of soybeans as a field crop by pioneering U.S. agriculturists in the late 1920s and early 1930s led to several important seed collecting trips to the Orient. Plant breeders have used these original seed sources, also referred to as germplasm, to develop most of the commercial soybean varieties used by growers today. While no one questions the success of soybeans as a crop and their enormous importance to U.S. agriculture and the economy, scientists are concerned about the limited genetic diversity within our commercial varieties. Fully 95 percent of all the genes in soybean varieties grown in the U.S. can be traced to a mere 35 ancestral lines from Asia. For varieties grown in Illinois, the situation is even worse: only three ancestors account for over 50 percent of the genes. Without the input of new genes, each generation of newly developed varieties actually becomes more closely related genetically. To continue improving our varieties, breeders must incorporate new genes into old varieties.

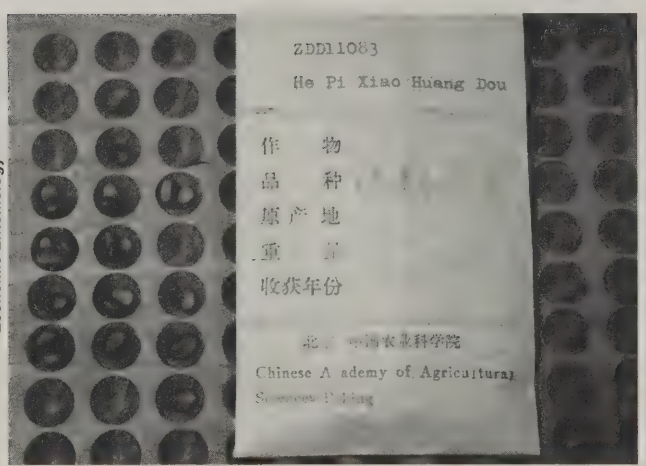


Photo by Charles G. Helm, INHS Center for Economic Entomology

Some of the newly acquired seeds of primitive varieties of Chinese soybeans.

In 1992, the USDA Soybean Germplasm Collection, located at the University of Illinois campus in Urbana, with the support of soybean farmers and the agricultural experiment stations of Illinois and Iowa, negotiated the acquisition of over 1,000 primitive soybean varieties from central and south China. This is perhaps the most significant germplasm acquisition in over 60 years, representing not only a significant numerical addition to the collection, but also the potential of genetic diversity not previously available to U.S. scientists. China is the center of diversity of soybeans and this is the first time in history that we have access to large quantities of germplasm from these areas.

A diverse team of scientists in Illinois, Iowa, and other states is currently evaluating these primitive varieties for traits that could be used directly to improve U.S. soybean varieties. This comprehensive evaluation includes an assessment of insect, disease, and nematode resistance; seed composition; drought tolerance; agronomic characteristics; and yield. Studies of this nature are time-consuming and expensive, but nonetheless essential investigations.

For instance, Illinois Natural History Survey entomologists have collaborated with USDA geneticists and plant breeders since 1970 to develop high-yielding, insect-resistant varieties adapted to the Midwest. While this cooperative effort has resulted in the development and release of improved breeding lines with usable levels of insect resistance, yield levels in all resistant releases have been too low for direct use by growers. However, if new sources of soybean resistance to insect defoliators were identified from within these new accessions from China, a potential breakthrough in this resistance versus yield impasse might be possible.

During the 1994 and 1995 growing seasons, new germplasm accessions were screened for resistance to leaf-feeding insects in both field and laboratory studies. Seven lines with levels of resistance equal to currently available breeding lines were identified as a result of these efforts. Although insect resistance is only a small part of the development of genetically improved varieties, this information will be combined with results of the analysis of the other broad range of traits included in this study. Preliminary results suggest that looking back into the soybean's past may be the best route to future improvements of U.S. soybeans.

Charles G. Helm, Center for Economic Entomology and Randall Nelson, USDA Soybean Germplasm Collection

New Survey Publication

Non-native Fishes Inhabiting the Streams and Lakes of Illinois

Illinois Natural History Survey Bulletin 35, Article 1

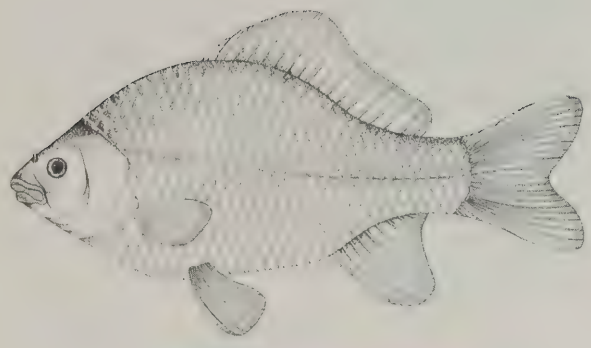
Christopher A. Laird

and

Lawrence M. Page

Provides illustrations, thorough descriptions, and diagnostic keys of 22 non-native fishes in Illinois. This publication is intended to assist in the identification and monitoring of the impacts of non-native fishes in Illinois.

To order, please contact the Survey Distribution Office, 607 E. Peabody Dr., Champaign, IL 61820, (217) 333-6880. $10 per copy.



Goldfish, Carassius auratus, *one of the non-native fishes featured in Bulletin 35, Article 1.*

Rootworm

continued from page 2

soybean fields. The eggs overwinter in the soil for a single season and after hatch occurs, the larvae begin to feed on corn roots in early June. If this hypothesis is proven true, corn production throughout the Corn Belt could be affected significantly. Why this egg laying in soybean fields is occurring is not known at this time.

Rapid dispersal of the western corn rootworm has occurred previously. This species was of little concern to U.S. corn production prior to the 1950s because this insect remained along the western edge (Colorado, Nebraska, and Kansas) of the major U.S. corn production area. As irrigation increased, western corn rootworms began to lay eggs in irrigated soils, many of which were treated with chlorinated hydrocarbon insecticides. In a few years, western corn rootworms developed a 1,000-fold resistance to these insecticides (aldrin and heptachlor). The resistant strain spread rapidly from a single location in southeastern Nebraska in 1961: by 1973, the entire Corn Belt was enveloped.

Corn producers in neighboring states are watching with apprehension as the situation in Illinois unfolds. Research is under way to keep crop rotation a viable option for corn rootworm management. If crop rotation fails as a management tool for corn rootworms, the economic impact could exceed $100 million for Illinois corn producers.

The use of crop rotation has, and continues to be, the main pest management strategy for corn rootworms in Illinois and across the Corn Belt. Since 1993, the incidence and severity of corn rootworm larval injury in first-year cornfields throughout much of east-central Illinois have increased. Producers in the following counties have been significantly affected most often: Champaign, Ford, Grundy, Iroquois, Kankakee, Livingston, McLean, Vermilion, and Will. Only very isolated cases of first-year corn larval injury have been reported outside this cluster of counties. In addition to east-central Illinois, some producers in northwestern Indiana have reported similar rootworm problems in corn following soybeans. Thus far, no other states have indicated that they are experiencing western corn rootworm larval injury in first-year cornfields, suggesting the problem is very isolated.

If producers in east-central Illinois experienced first-year corn larval injury and found western corn rootworm adults in adjacent soybean fields in 1995, they should consider the use of a soil insecticide in corn following soybeans in 1996. This recommendation will remain in effect until more complete explanations and economic thresholds can be determined. Growers outside of east-central Illinois are strongly encouraged not to use a soil insecticide on first-year corn for rootworm control as a standard practice.

Photo by Eli Levine, INHS Center for Economic Entomology

Western corn rootworm beetle feeding on soybean flowers.

We gratefully acknowledge funding from the Illinois Council on Food and Agricultural Research (C-FAR) that supported this research.

Eli Levine and Michael Gray, Center for Economic Entomology

Species Spotlight

Shooting Stars

Susan Post

By staring at the sky long enough during a spring evening, one might be rewarded with the sight of a shooting star or two. Spending several daylight hours in a prairie or open woods during the spring could also yield shooting stars—hundreds of them, of the plant variety.

Shooting stars are perennials belonging to the genus *Dodecatheon*. They have a smooth, hollow, unbranched stem that holds a cluster of rose-, white-, or lilac-colored flowers, above a basal rosette of light green oval leaves. Each flower in the cluster is 1 to 1.5 inches long with five strongly backward-pointing petals. At the tip of each flower, the five yellow stamens surround a single pistil in a cone-shaped arrangement that gives the illusion of speeding motion.

Photo by Michael Jeffords, INHS Center for Economic Entomology

The common shooting star, Dodecatheon media.

The flower stalks curve so that the flowers nod when they are in bloom. Following pollination by bees, the ovary grows into a brown, paper-thin fruit. As the fruits ripen, the flower stalks straighten so that when the fruits are mature the flower stalks are erect. The fruit is a capsule containing numerous tiny seeds that mature and are released in late summer. Despite the seeds' small size, they are relatively heavy and the wind does not carry them very far.

The unusual shape of the petals and stamens gave the plant its common names—mosquito bills, birdbills, and shooting star. The similarity of the plant to the English primrose, or cowslip, has led to the name "American cowslip." The name "prairie pointers" was given to the plant by early settlers during a time when both prairies and the plant were much more common.

Illinois has three representatives of the genus *Dodecatheon*, all blooming from mid to late spring. The most abundant member is *Dodecatheon media*, the common shooting star, which can be found throughout the state. The plant is found in open, dry woods or prairies. *Dodecatheon amethystinum*, the jeweled shooting star, grows on north-facing cliffs and bluffs lining the waterways of the Illinois and Mississippi rivers that are exposed to northwest winds. The plants typically grow in thin soil just above or below a limestone or dolomite outcropping. When the plants bloom in early May, the rocky slopes are clothed in a blanket of pink that can be seen from the highway below. The plant has magenta flowers and a small, frail fruit (the common shooting star has a tough fruit).

The final species, *Dodecatheon frenchii,* is named after Southern Illinois University botany professor George Hazen French, who first discovered the plant in 1871. The plant grows under the drip lines of sandstone ledges, where the sandy soil is very moist during the plant's growing season. In Illinois, French's shooting star is restricted to a belt approximately 10 miles in width called the Shawneetown Ridge. The plant appears to be smaller than the common shooting star, and French's shooting star has twice as many chromosomes as the common species.

When seeking shooting stars, whether at Bell Smith Springs for French's shooting star, Mississippi Palisades State Park for the jeweled shooting star, or your local prairie remnant for the common shooting star, always remember to look down, not up!

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Prolific Pollinators!

Objective: to learn about some of the different flower types and the animals that pollinate them

Materials: multiple copies of **Prolific Pollinators!**

Vocabulary: evolve, pollinator, pollination

Comments: Flowering plants and insects evolved together, and insects were the first animals to serve as pollinators. Modern flowering plants can have very elaborate floral adaptations that are designed to attract specific types of pollinators. These pollinators include bats, birds, and various insects from beetles to bees to flies to moths. To be an effective pollinator, an animal must visit flowers in search of pollen or nectar and move pollen from flower to flower during its visits. These are a few examples of pollinators and the flowers they like: bats and moths attracted to night-blooming white flowers ; pollinators with long tongues feeding on trumpet-shaped flowers that have much nectar hidden deep within them; flies attracted to rotten-smelling flowers; and hummingbirds that like the color red.

Procedure:

1. Introduce the subject of flower pollination by animals with the material presented above.

2. Distribute copies of **Prolific Pollinators!** and have students match organisms in column 1 with appropriate pollinators in column 2. *Answers: 1 C; 2 A, F; 3 A, F; 4 B, F; 5 G, B.*

3. Have students try to name other animals that might pollinate these flowers.

The Naturalist's Apprentice

Prolific Pollinators!

Michael Jeffords

Prolific Pollinators!

Many flowers have shapes that lend themselves to pollination by a very few types of animals. Observe the shape of the flowers in column 1 and try to choose appropriate pollinators from column 2. Some flowers may have more than one type of pollinator. Under some flowers is a hint as to its color, fragrance, or blooming time.

Column 1

1.

(rotten meat odor)

2.

3.

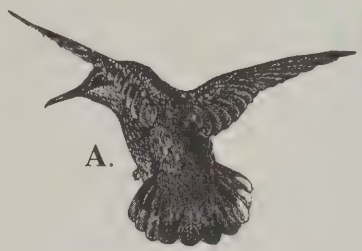
(bright red)

4.

5.

(blooms in evening and night)

Column 2



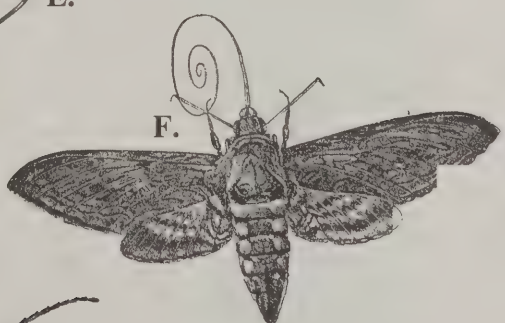
A.

B.

C.

D.

E.



F.

G.

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Fish communities

continued from front page

carp might be expected to decline in abundance due to increased predation on their young and increased competition with other species.

Analysis of more than 30 years of data has shown that Illinois River fish communities have significantly changed since the 1960s. On average, 11 species accounted for 95 percent of the fish collected on the lower river in both the 1960s and 1990s; however, in the 1960s, carp tended to dominate catches, averaging 42 fish per hour of collection, while bluegill averaged 8 per hour. In the 1990s, carp dropped to an average of 8 per hour, and bluegill increased to 34 per hour and dominated catches from the lower river.

On the middle and upper river, 95 percent lists averaged 9 and 6 species in the 1960s, respectively, and 14 species on both segments in the 1990s. Carp declined from averages of 57 per hour on the middle river and 35 per hour on the upper river in the 1960s to 14 per hour and 6 per hour, respectively, in the 1990s. Bluegill increased from averages of 8 per hour on the middle river and less than 1 per hour on the upper river in the 1960s to 27 per hour and 12 per hour, respectively, in the 1990s. In recent years carp rarely dominated catches in any river segment, and fish communities were more evenly distributed among a greater number of species than in the 1960s. But because carp can be very large, they continue to be a major proportion of the total catch weight. The most noteworthy changes have occurred on the upper river, historically the most degraded segment due to its nearness to Chicago area pollution sources. For example, in 1962 and 1963, just four species made up the 95 percent lists: gizzard shad (*Dorosoma cepedianum*), emerald shiner (*Notropis atherinoides*), carp, and goldfish (*Carassius auratus*)—a species with pollution tolerance similar to carp. In contrast, 10 species made up the 95 percent list for 1995; species on this list included the bluegill, largemouth bass (*Micropterus salmoides*), orangespotted sunfish (*Lepomis humilis*), and several species of small minnows. The carp was not on the 95 percent list, and although the goldfish was not collected, the carp x goldfish hybrid was collected at a rate of less than 1 per hour.

Improved water quality (e.g., higher dissolved oxygen concentrations) resulting from better pollution control since the 1960s is probably the best explanation for the observed changes in fish communities, despite continuing habitat deterioration from siltation. Additional stress to the system may result from increases in commercial navigation traffic and from reproducing populations of new exotic species: grass carp (*Ctenopharyngodon idella*), zebra mussel (*Dreissena polymorpha*), and a minute crustacean called *Daphnia lumholtzi*. In fact, the U.S. Army Corps of Engineers is currently conducting a feasibility study for expanding the river's navigation capacity. The fish population monitoring program will be useful for tracking further changes in fish communities and for evaluating the effects of new system-wide stresses.

Thomas V. Lerczak, Center for Aquatic Ecology

Photo by INHS staff at Havana

Electrofishing rig being operated by Havana LTRMP staff.

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ILLINOIS NATURAL HISTORY SURVEY

Reports

July/
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No. 340

INSIDE

Eastern Bluebirds: Effects of Environment on Reproductive Strategies

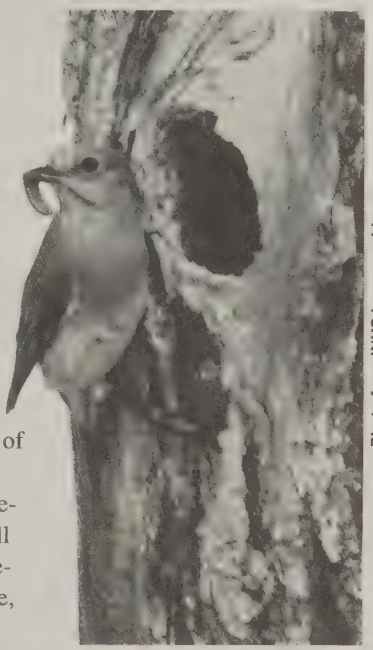


Photo from INHS image archives

*Male eastern bluebird (*Sialia sialis*).*

Anyone who studies bluebirds hears the same comments: "I haven't seen a bluebird in thirty years!", or "Are bluebirds still around?" In the early 1900s, bluebirds were a common sight in suburbs and rural areas. By the middle of the century, however, populations had shrunk to one-tenth of their original numbers. Several factors contributed to this decline, including loss of nest sites due to new agricultural practices (trimming dead snags and replacing wood fence posts with metal) and competition with introduced starlings and house sparrows. Only with the construction of bluebird trails, consisting of nest boxes erected and monitored for bluebird use, have populations rebounded in recent years.

The history of the bluebird is a good example of how the physical habitat and biotic community in which animals live affect their survival and fitness. For birds, habitat structure determines the availability of nest sites, availability and accessibility of food resources, and the types and densities of predators and nest-site competitors. In addition, because environmental conditions vary among habitats over time, and may alter the success of a given reproductive strategy, there must be some degree of behavioral flexibility involved. All of these factors influence the decisions that breeding birds make, as well as their ultimate fitness. By examining links between reproductive performance and the breeding environment, this decision-making process and the development of life histories can be better understood.

A study is currently under way to determine how environmental factors influence the reproductive behavior and success of the eastern bluebird, a cavity-nesting songbird, in central Illinois. From 1992 to 1994, reproductive traits, behavior, and success of box-nesting bluebirds in three different habitats (early successional, agricultural, and forest edge) were monitored. We found that nesting habitat did not seem to affect reproductive strategies and there was no difference in the proportion of boxes used in each habitat group. In addition, neither clutch size nor nestling mass (an indicator of nestling quality) differed across habitat groups. The groups, however, did differ in terms of productivity. Early in the season, nests along forest edges produced a lower proportion of fledglings than those in the other groups. This is probably due to nest-site competition from house wrens that set up territories during this time, and because shrubby and forest edge habitats are a known source of nest failure in bluebirds. Late in the season, nests in agricultural areas were less productive than those in other habitats. During this time, wren aggression decreases as they raise their own young. Also, vegetation in agricultural habitats is tall and dense, limiting bluebird foraging ability

Continued on back page

Photo by Jeff Brawn, INHS Center for Wildlife Ecology

Researchers capturing an incubating female bluebird to be weighed and banded.

The Distributions of Aquatic Organisms in the Central Highlands

With over 800 species, North America has the most diverse temperate freshwater fish fauna in the world. The region containing both the greatest number of species and the highest amount of endemism (i.e., native to, and restricted to, a particular geographic area) is the Central Highlands (Fig. 1), which is divided into three distinct geographical areas: the Ouachita Highlands in Oklahoma and Arkansas, the Ozarks in Missouri, and the Eastern Highlands, with the the Shawnee Hills of southern Illinois forming a "land bridge" connection between the Ozarks and Eastern Highlands.

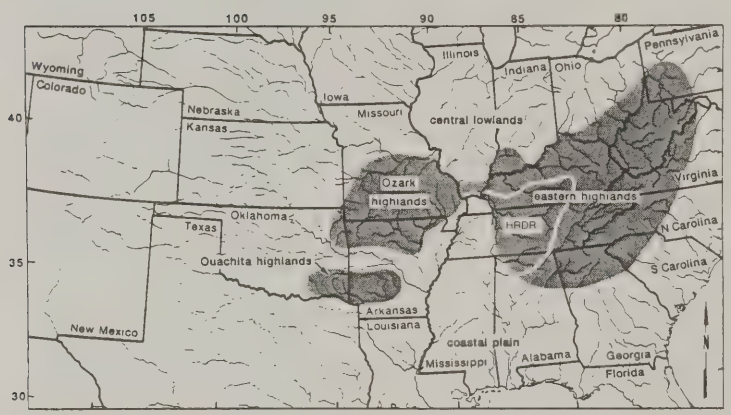


Figure 1. The Central Highlands of North America. (From Mayden 1987, Kansas Geological Survey Guidebook Series, Quaternary Environments, Pleistocene Glaciation and Historical Biogeography of North American Central-Highland Fishes. W.C. Johnson, editor. 208 pp.)

Within the Central Highlands, the most species-rich area is a physiographic region termed the Highland Rim and Nashville Basin Drainage Realm (HRDR). The HRDR (Fig. 1) encompasses the lower Tennessee River system, the Cumberland River drainage below Cumberland Falls, most of the Green River system, and a few additional watersheds. With over 300 species of fishes, the HRDR harbors the most diverse freshwater fish fauna of any temperate region of comparable size on the planet, and probably has the most diverse mussel and crayfish fauna.

Within the Highland Rim, as throughout the Central Highlands, the fishes showing the most complex distribution patterns are the species inhabiting the small headwater streams. These species include darters, minnows, and madtom catfishes. The adults breed and spend their whole lives in the headwater streams and, even though the young-of-the-year may get washed into larger streams, they usually move back up to the headwaters within a few months. These fishes cannot complete their life cycles in the larger riverine habitats, which are almost as much a dispersal barrier to them as dry land.

Most intriguing about the HRDR, and the Central Highlands in general, are the patchwork distributions of many of the native organisms. For example, the fringed darter, *Etheostoma crossopterum*, (Fig. 2) occurs throughout the lower Cumberland River system, but is limited in the Tennessee River system to small sections of the Duck River, Buffalo River, and Shoal Creek systems. Additionally, there are two disjunct populations occurring in streams draining directly into the Mississippi River in western Tennessee.

With little knowledge of the biology of the species, it is difficult to imagine how such a distribution could have resulted. One hypothesis might be that the fringed darter once was dispersed throughout the Cumberland and Tennessee River systems but has undergone widespread extirpation in the Tennessee system. Fortunately, we do have an understanding of the life history characteristics of the fringed darter, and we know that the species is incapable of long-distance dispersals. An alternative hypothesis is that the present-day drainage systems did not always exist (see Fig. 3), and that the species' disjunct distribution represents ancient stream patterns.

The factors affecting the distributions of species include biological phenomena, such as behavior and habitat selection, and geological phenomena, such as plate tectonics and stream captures. Geological events can split the range of an ancestral species and isolate populations that subsequently differentiate. Clearly, the geological evolution of drainages and biological evolution of native aquatic organisms are closely related, and studying one should provide information about the other. Unfortunately, the geologic data alone are insufficient to recon-

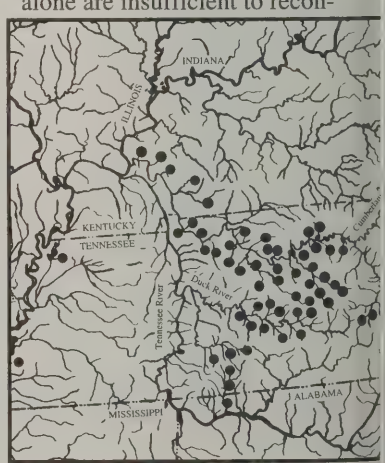


Figure 2. Distribution of the fringed da
Etheostoma crossopterum.

Continued on next page

struct detailed patterns of historical drainage connections. With this in mind, researchers at INHS are studying the "phylogeography," or the combination of biogeographic and phylogenetic information (i.e., hypotheses of species relationships) of native species, in an attempt to better understand how species came to exhibit their present-day distribution.

In phylogeographic analysis (Fig. 4), the first step is to construct phylogenies for the various groups of endemic organisms (Fig. 4A, species A-I; species B and C are most closely related, and these two form the "sister

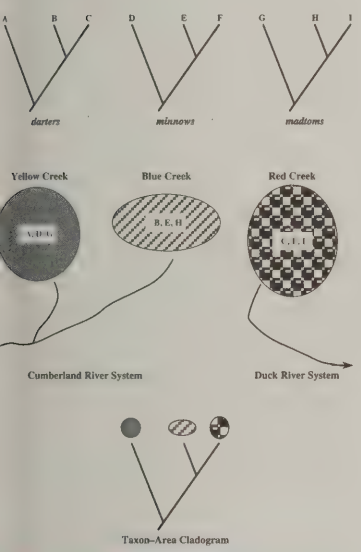


Figure 4. Phylogeographic analysis. See text for explanation.

group" to species A). The second step is to develop taxon-area cladograms – simply replace the names of the species with the names of the areas in which they occur. In Fig. 4B, species A, D, and G occur in Yellow Creek, species B, E, and H occur in Blue Creek, and species C, F, and I occur in Red Creek, so the resulting taxon-area cladogram for each independent group of organisms (darters, minnows, and madtoms) looks like Fig. 4C. The final step involves combining the various taxon-area cladograms to see whether they show patterns of congruence. In our simplified example, all three groups of fishes share the identical phylogeographic pattern (Fig. 4C).

Because a vicariant event, such as stream capture, affects several taxa simultaneously, the resulting pattern should be reflected in the distributions of several species. If distribution patterns are due entirely to dispersal, similar habitats in continuous (connected) streams and drainages (Fig. 4B, Yellow and Blue creeks) should possess biotas that are most closely related to each other, whereas adjacent but discontinuous stream systems (Fig. 4B, Blue and Red creeks) can be expected to contain more distantly related groups of organisms. However, if vicariant events have contributed to distribution patterns, adjacent but discontinuous streams are expected to contain organisms that are most closely related to each other (e.g., Species E and F, H and I).

Looking again at the fringed darter, it is more parsimonious (simple) to hypothesize that populations of the fringed darter were transferred from tributaries of the Cumberland River to tributaries of the Tennessee River (or vice-versa) through headwater capture events than it is to assume the species was once widespread but has undergone numerous extirpation events. The now highly disjunct populations of the fringed darter inhabiting streams in western Tennessee are populations that survive in the only remaining suitable habitat in western Tennessee where the Tennessee and Cumberland rivers once flowed.

We must have a thorough understanding of the distributions and phylogenetic relationships of the various groups of endemic organisms in order to understand the impact of historical factors on

Figure 3. Hypothesized preglacial drainages in eastern North America superimposed on exisitng drainage patterns. (From Mayden, 1988, Vicariance biogeography, parsimony, and evolution in North American freshwater fishes. Systematic Zoology, 137(4).)

the present-day distributions of these organisms. While examining populations of two species of fishes related to the spottail darter (*Etheostoma squamiceps*), a fish present in the streams of the Shawnee Hills of southern Illinois, Survey scientists recently discovered and described five new species of darters inhabiting the HRDR. Also, Survey scientists just completed work that indicates that populations of the orangethroat darter (*E. spectabile*), another inhabitant of Illinois waters, actually represent a composite of six undescribed species occurring in the HRDR (one species, *E. forbesi*, was named after Stephen A. Forbes, first Chief of INHS). Using a combination of molecular techniques, researchers are beginning the task of examining geneological relationships that will allow them to develop phylogenies for these endemic groups of fishes. The resultant phylogeographic data will then be used to develop the first detailed explanations of the evolutionary history of the present-day river systems of the HRDR and offer explanations regarding the complex distribution patterns of fishes.

Patrick A. Ceas and Lawrence M. Page, Center for Biodiversity

Trophic Cascades in Ecosystems

Wolves eat moose and moose eat fir needles on Isle Royale in Lake Superior. This food chain is in some form of balance, but suppose that wolves are artificially stocked, say doubling their numbers. In response, we expect fewer moose and more fir needles. The stocking of wolves creates a kind of alternating ripple effect that changes the numbers of organisms in various levels of the food chain. This is called a "trophic cascade" and has been observed in a number of lakes and a few terrestrial systems, disturbed from the top down. However, the magnitude—the percent change in the biomass at each trophic level—of the changes often diminishes at lower trophic levels. In addition, we can imagine perturbing a food chain at the bottom, say by increasing light or nutrient levels. Then we would expect more producers (green plants), more herbivores, more carnivores—all changes of the same sign as we go up the food chain, or at least none of opposite sign. This is also often, but not always, seen. (See Fig. 1.)

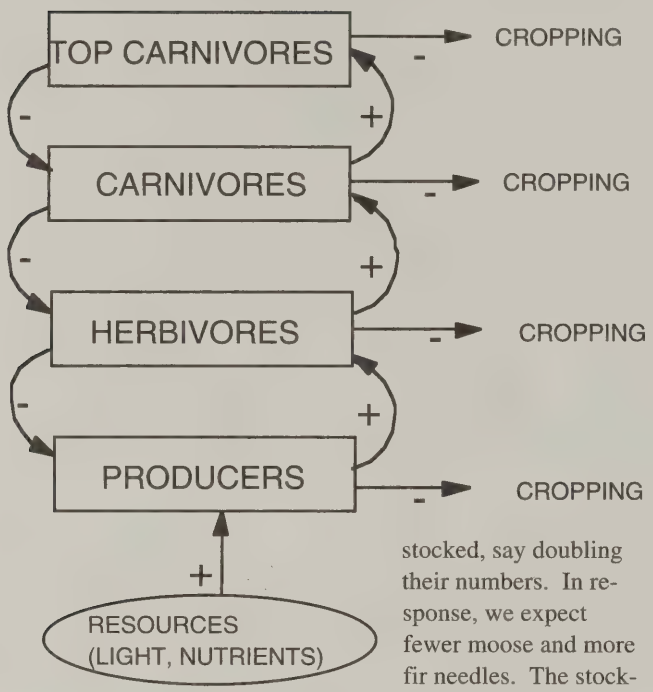


Fig. 1. Four-level food chain. Signs of influence are indicated. Bottom-up influences are all positive: increasing producers tends to increase herbivores. Top-down influences are negative: increasing carnivores tends to decrease herbivores. Cropping reduces each respective compartment's biomass. Stocking would be represented as negative cropping.

The trophic cascade is a potential management tool (for example, for controlling aquatic vegetation by controlling carnivorous fish), and its details reveal much about the interactions between trophic levels and the control of ecosystems. This subject goes back at least to a controversial 1960 paper by Hairston, Smith, and Slobodkin who, observing that the earth is green (and not overgrazedly brown), conjectured on how producers, herbivores, and carnivores interact...all with no equations.

Both top-down and bottom-up influences occur in the same system, and a proper theory incorporates both mechanisms simultaneously. Figure 1 shows the interactions in a four-level food chain subject to cropping and to manipulation of the available resources.

Early in the discussion there was a tendency to talk of top-down and bottom-up effects as mutually exclusive. After listening to colleagues and their strongly held opinions, I began to feel that the problem represented by Figure 1 had strong analogies to the physics of magnetism (a food chain was just a linear chain with nearest-neighbor interactions). While only nearest neighbors in the food chain interact directly, all compartments interact indirectly as they respond to changes in resources and to cropping. Rather than use the rusty machinery from magnetism, I sought intuitive arguments of how the trophic cascade should pop out of Figure 1. The arguments were not very convincing, and each time a Survey colleague reviewed them, he asked for more rigor. The final stroke came when a well-respected systems ecologist and modeller with a physics background said, "You may not be right." Then I dusted off the mathematics and solved the problem exactly.

The resulting approach combines all interactions shown by arrows in Figure 1. The crux of how one level impacts another is the degree to which a preyed-upon level can compensate its reduced biomass by capturing more of its prey. With high compensation, top-down effects diminish rapidly at lower trophic levels, which is often seen experimentally. For the particular type of predator-prey interaction known as ratio dependence (which is part of a continuing debate), the trophic cascade should produce changes that alternate in sign and diminish by a factor of roughly ten at each successively lower level. In that case a 10% increase in the top carnivore biomass will produce changes of -1%, +0.1%, and -0.01% in carnivores, herbivores, and producers, respectively. The last of these is likely undetectable over experimental noise, and hence consistent with some observations that the trophic cascade disappears around the level of zooplankton. On the other hand, the same system shows changes of the same sign and magnitude for a bottom-up perturbation, which is sometimes observed.

If instead "prey-dependent" predation (the basis of the Lotka-Volterra predator-prey equations) is assumed, the trophic cascade is not seen. Rather than a pattern of (+ - + -), we see a pattern (+ 0 + 0), which is suspected in some river systems.

Continued on page 8

Using Natural Enemies for Pest Control

Biological control means intentionally using natural enemies—predators, pathogens, or parasites (or parasitoids)—to control pest populations. Biological control has been successful against many pests, including stemborers, the species on which we focus our laboratory work. Biological control approaches include reuniting accidentally introduced pests with their exotic natural enemies, as well as creating novel associations by using a natural enemy that attacks a host that is closely related to the target species. We are trying to understand how novel-association natural enemies operate, how to use them effectively, and how to use these natural enemies safely so they do not harm nontarget species. Our goal is to develop tactics to use against stemborers, including the European corn borer, a serious corn pest in Illinois.

Stemborers attack grass crops, such as corn, sorghum, rice, and sugarcane. In our lab we have three species of Old World wasps (Braconidae) in the genus *Cotesia* that attack stemborers in those various grass habitats. One of these, *Cotesia flavipes*, originally from Asia, has controlled sugarcane borers in Texas for over 20 years. The other species are from Japan and Kenya. The adult wasps are about 3 mm long, live 1-2 days, and insert, in a matter of seconds, 30-80 eggs into a host larva, inside which the parasite larvae develop. After 12 days, the parasite larvae chew their way out of a dying host and spin cocoons. A week later, adult wasps emerge from the cocoons and search for a new host.

Our lab is trying to determine the kinds of cues parasitic wasps use to find habitats and hosts, and to understand the physiological interactions between parasites and their hosts.

Parasites use cues that allow them to find a habitat in which their hosts reside. By responding only to certain cues, parasites do not search aimlessly, but limit searching to appropriate habitats. Our braconids respond to volatile chemicals emitted by plants used by stemborers, whether stemborer hosts are present or not. One Ph.D. student, Claire Rutledge, exposes wasps to cues from different crop and noncrop grasses, and to nongrass plants, to see if the wasps prefer certain plants. She has found that each wasp species has its own likes and dislikes. Each parasite finds certain grass crop plants more attractive than others, is equivocal about some native grasses, and definitely finds some nongrass plants unattractive. This allows us to hypothesize that each species will use only habitats containing grasses, but that each species will prefer a different habitat. Next, we will add stemborer larvae to the test plants to see if less-attractive plants become more attractive when stemborers feed in them. Knowing plant preferences and the degree of habitat fidelity the parasites show allow us to predict whether these natural enemies can negatively impact nontarget species.

A second Ph.D. student, Marianne Alleyne, is testing what happens after the parasite oviposits into a host. Several outcomes of parasitization can occur: the parasite uses the host successfully (parasite wins), the host kills the parasite progeny (host wins), or intermediate outcomes in which neither host nor parasite wins. We have seen all of these outcomes, indicating differences in physiological compatibility between the wasps and stemborer hosts. For parasitization to succeed, attacked hosts must provide parasite progeny with sufficient nutrition for development and a safe place to develop. On the other hand, some hosts can kill the parasite progeny by a process called encapsulation. Hosts have circulating blood cells (hemocytes) that initiate an immune response when the host is invaded by parasite eggs. Encapsulation is one immune response that hosts use to defend themselves against parasites. In turn, some parasites can defuse the immune response by interfering with the ability of the hemocytes to recognize and encapsulate parasite progeny. It is this interplay of response and counter-response that Marianne will tease apart to find mechanisms that determine the different outcomes of parasitization and test whether different hemocyte types are responsible for differences in the immune response.

Both avenues of research may seem basic and possibly esoteric, whether determining the roles of hemocytes or the kinds of plant odors parasites like. Yet these kinds of basic research are what we must pursue to develop applied solutions. Following both lines of research will allow us to predict both the utility and safety of using certain parasites against specific stemborer hosts. Parasites have a range of hosts they can and will attack, whether that is determined ecologically—by choosing only certain habitats, or physiologically—by developing only in certain hosts. Our task is to determine the physiological and ecological host ranges and to develop the means to deploy parasites against those hosts. Only with those kinds of information can we make informed decisions and predict the safety and utility of using natural enemies for biological pest control.

Robert Wiedenmann, Center for Economic Entomology

Photo courtesy of Department of Entomology, Texas A&M University

Braconid wasp, a stem borer parasite, searching near entrance of tunnel inhabited by stem borer larva.

Species Spotlight

Cecropia Moth

Susan Post

Although the typical robins of spring spend most days eating worms, this "robin" eats nothing at all and wanders around in the moonlight. Known as the robin moth in England, in the United States this large silk moth is the familiar cecropia, *Hyalophora cecropia*. Cecropias are found in the eastern half of the U.S. except for the southernmost areas. In Illinois, cecropias are almost absent from mature woodlands; they prefer newly settled suburban areas with small shade trees. This behavior earns the moth the title of "fugitive species" because its populations are constantly shifting to disturbed areas. The reason for its preference for urban areas is simple—its major predator, the white-footed mouse, is absent. The house mouse, common in urban areas, cannot open the cecropia's cocoons and the pupae have a safe haven.

Photo by Michael Jeffords, INHS Center for Economic Entomology

The Cecropia moth, Hyalophora cecropia.

Cecropia moths emerge mid-morning from their cocoons during mid to late-May. Once the moth has emerged, it appears to be all head and abdomen. The wings hang limp and are wet and small. A resting place is soon found and the moth begins a pumping motion—forcing blood into its wings. Once the wings have expanded and hardened, they will be 5 to 6 inches across, colored a dark, red-brown with silver-gray highlights. The moth will then remain motionless for the rest of the day.

Male moths will make a brief flight before dusk and then remain hidden until just before dawn when they go in search of a female. Females, heavy with eggs, remain where they are. Just before dawn, the female will send out a pheromone, an airborne scent that will attract the males. Using the scent receptors on his featherlike antenna, a male will follow the pheromone trail until he locates the female. They mate and remain coupled until the following dusk. Shortly thereafter, the male flies away and will search for another female during the next near-dawn period. The female moth, however, begins to lay large, oval cream-colored eggs in groups of three to six. The first eggs are laid near where the female originally pupated. After laying this first group, she flies away (the first time she has tried out her wings) and lays the remaining eggs on proper foodplants (far apart from each other to minimize competition for food among her caterpillars). Food plants include apple, white birch, white oak, black cherry, and several other tree species. The female will lay about 350 eggs. The adult moths have a life span of only 5 to 6 days and do not feed.

The young cecropia larvae are black and covered with bristles, and, unlike their parents, are eating machines. By late summer, the fourth and final instar larvae are large greenish caterpillars with four orange tubercles on their thoracic segments. When full grown, the larvae stop eating and descend to near ground level to spin cocoons among the stems of a shrub. This cocoon, the largest woven of any moth, has three layers—a tough leathery outer covering, a fluffy layer that suspends the inner within the outer layer, and an even tougher inner layer in which the pupae rest. The developing moths spend the winter in their cocoons and metamorphose the following year into the next generation of night-wandering robins of the spring.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Chemical Cues

Objective: to learn how insects use chemical cues to locate each other

Materials: multiple copies of **Chemical Cues**

Vocabulary: molecule, nocturnal, pheromone

Comments: Most organisms, both plants and animals, must periodically get the sexes together to produce the next generation of young. Insects have evolved any number of ways to do this, but one of the most interesting methods is demonstrated by moths. Female moths release a specific chemical into the air (called a pheromone) that can be detected by male moths of the same species. The males use their two antennae (often very feathery) to detect the chemical trail in the air and home in on the female. Some male moths, like the cecropia featured in *Species Spotlight*, can detect this scent trail up to a mile or two away! These chemical pheromones are very specific, and each species of moth has its own special chemical attractant.

Procedure:

1. Introduce the subject of pheromones from the above material and that found in *Species Spotlight*.

2. Distribute copies of **Chemical Cues** and have students find the correct chemical pheromone trail from the male to the female. Students should draw a line that passes lengthwise through each correct chemical molecule leading the male to his mate.

3. Discuss additional ways in which organisms may use chemicals to alter the behavior of other organisms *(i.e.,release smells to ward off predators, release odors to attract pollinators, use chemicals to mark territories).*

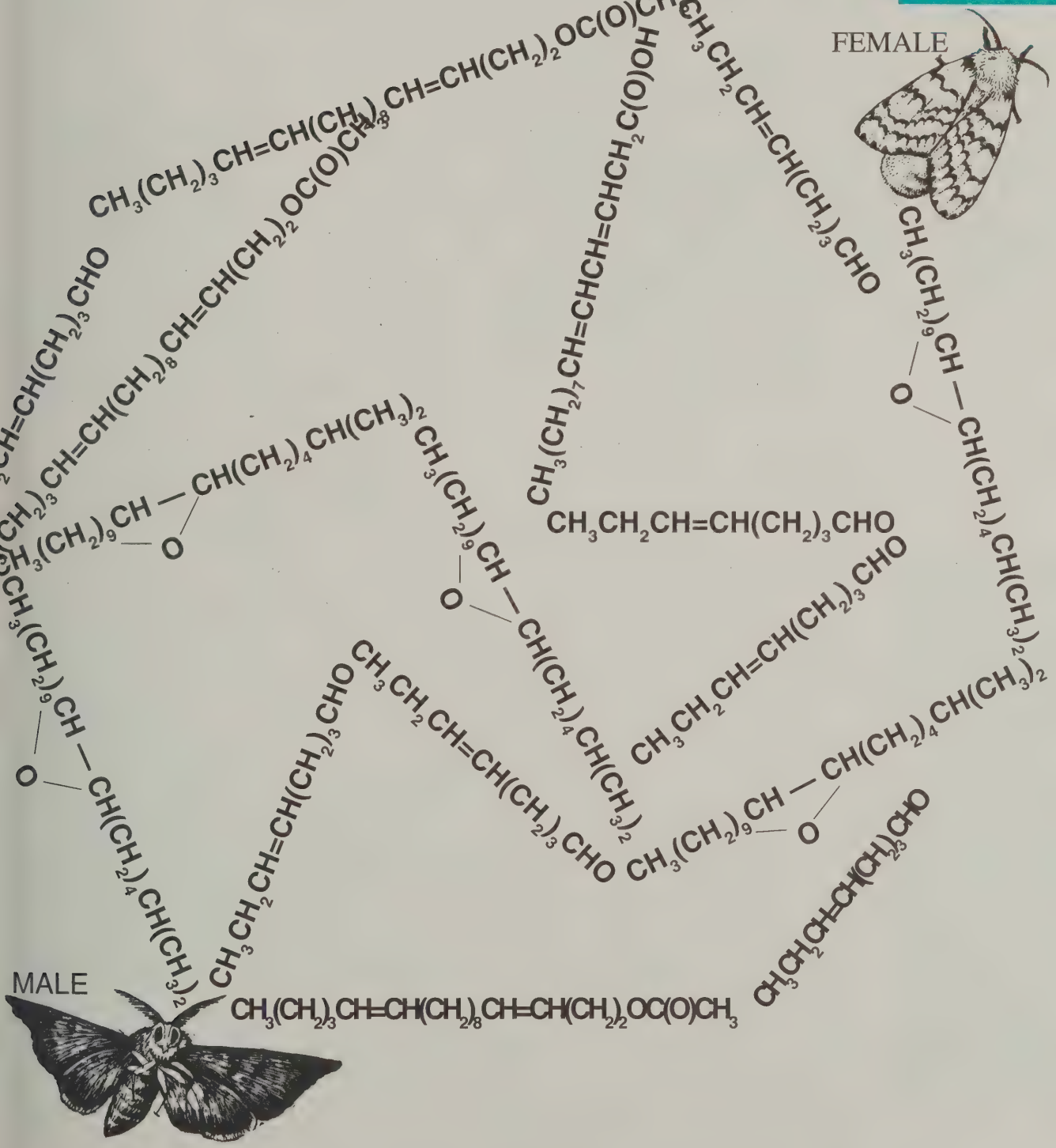
The Naturalist's Apprentice

Chemical Cues

Michael Jeffords

Chemical Cues

Moths use chemical cues, called pheromones, to help the sexes get together. Since most moths are nocturnal (active at night), this method is very efficient. Each species of moth has its own special chemical that is released by females to attract males. Locate the pheromone being released by the female gypsy moth and trace a path the male gypsy moth must follow (passing lengthwise through all the correct molecules of pheromone) to locate his mate.



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Bluebirds

continued from front page

and increasing cover for nest predators.

To further document the effects of environmental factors on avian reproductive strategies, an experiment is currently under way that manipulates food availability and risk of nest predation. Active nests are assigned to one of four treatment groups: supplemental food/increased nest predation risk, supplemental food/normal nest predation risk, normal food availability/increased nest predation risk, and a double control. At nests receiving supplemental food, 200 mealworms are provided near the nest every other day during the nestling. Nest predation risk is simulated by presenting a nest predator model (rubber snake) on and near the box several times during the nestling phase. In addition to monitoring reproductive success, behavioral watches are done to assess the effect of the treatments on parental foraging and nest-guarding behaviors. Comparing reproductive success and parental behaviors among treatment groups will help us to understand the strategies used by parents under different environmental conditions. This study began in 1995 and will conclude in 1996.

As more and more land is modified and disrupted by human use, it is beneficial to know how these changes will affect populations of plants and animals. Bluebird productivity is affected by the surrounding habitat, both natural and man-made. Cavity-nesters are often nest-site limited, and thus may be forced to breed wherever there are adequate nest sites. Other species may be affected in different ways, perhaps in their behavior or long-term fitness.

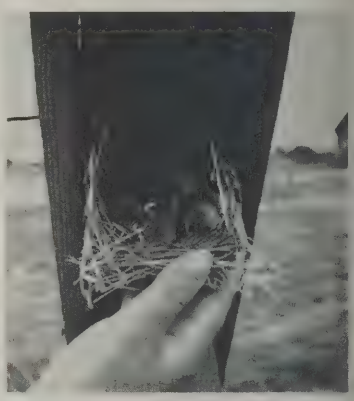

Photo by Jeff Brawn.

Brood of five bluebird eggs in a Peterson-style nest box.

Laura R. Lee, Department of Ecology, Ethology, and Evolution, University of Illinois; Jeffrey Brawn, Center for Wildlife Ecology

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Cascades

continued from page 4

The approach I have developed seems to be able to predict essentially all observed patterns in experiments. Future work will include testing this claim more carefully. As usual, there will be the necessary job of testing a theory that is logically satisfying, but based on many simplifications, against real biological mechanisms and data. Complicating factors include:

1. the fact that food chains are often actually webs, in which case the theory here breaks down,
2. the difficulty of applying a theory based on steady state to real dynamic systems,
3. the complexity of real predator-prey interactions, including prey shifts at different life stages and under different environmental conditions,
4. the possiblity that the predicted effects are too small to detect experimentally.

Reference:
Herendeen, R. 1995. A unified quantitative approach to bottom-up:top-down and trophic cascade hypotheses. Journal of Theoretical Biology 176:13-26.

Robert Herendeen, Center for Aquatic Ecology

ILLINOIS NATURAL HISTORY SURVEY

Reports

September/
October 1996
No. 341

INSIDE

Can We Restore Elk to Southern Illinois?

Illinois is at the center of the historical range of the eastern race of North American elk (*Cervus elaphus canadensis*). This subspecies is now believed to be extinct, having been extirpated in Illinois by 1850. Existing wild populations of elk occupying the former range of eastern elk (principally in Michigan and Pennsylvania) are descendants of Rocky Mountain elk (*C. e. nelsoni*), translocated from the area near Yellowstone National Park.

In the fall of 1995, members of Illinois' General Assembly directed the Illinois Department of Natural Resources (DNR) to study the feasibility of reestablishing a wild population of elk in Illinois. Elk reintroductions have been tried many times, but success has been varied. Most failed attempts have been due to poor-quality habitat and land use/land owner conflicts. Successful reintroductions require large amounts of high-quality habitat and low human density. Three of 8 attempts succeeded in the plains states (Oklahoma, South Dakota, and Texas) while only 2 of 10 attempts succeeded in the East (Michigan and Pennsylvania).

Photo by Tim Van Deelen, INHS Center for Wildlife Ecology

*Elk bull (*Cervus elaphus nelsoni*) at Yellowstone National Park.*

The research by the Illinois Natural History Survey (INHS) was intended to provide resource managers in the DNR with a preliminary assessment of the habitat available to support a reintroduced population of elk in southern Illinois and identify promising release sites relative to habitat, land ownership, agriculture, and road densities.

The Illinois Geographic Information System (GIS), which is housed at INHS, was used to identify elk habitat in southern Illinois. GIS is a sophisticated set of computer programs designed to manipulate, process, and analyze map data. The map data we used came from aerial photography and remote sensing, most of which was generated for other Survey projects. Using the programming expertise of INHS scientists Tony McKinney and Mark Joselyn, we first "told" GIS what elk habitat should look like and then "asked" it where similar habitat existed in southern Illinois.

Published studies of elk habitat use indicate that a 50-50 mix of foraging areas (grasslands and shrubby areas) and cover (forests) is optimal. Other factors must be considered when selecting potential release sites. For example, elk are very sensitive to human disturbance, so road densities must be low and human activity must be minimal. Elk also need lots of room, so isolated areas that have a suitable mix of forage and cover with low human disturbance may still be

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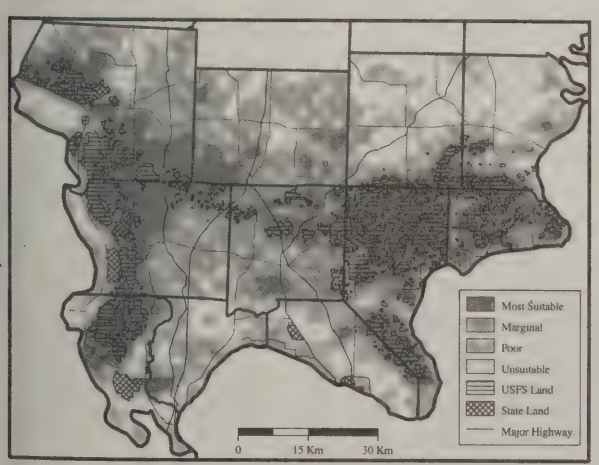


Potential elk habitat in southern Illinois.

Using Biological Control to Lose Loosestrife in Illinois

Late in the summer, many wetlands throughout northern Illinois and the upper half of the U.S. turn into seas of bright pink-purple. Although pretty from a distance, the beauty is deceiving. The sea of purple is due to the invasion and takeover of wetland habitats by an exotic weed—purple loosestrife.

Photo by Dave Voegtlin, INHS Center for Economic Entomology

Purple loosestrife running rampant in northern Illinois.

Purple loosestrife is a European perennial that invaded the U.S. over a century ago. In Illinois, it has become a serious pest in the last two decades, crowding out native vegetation in once-pristine sedge meadows, bogs, and other high-quality wetlands. With few herbivores feeding on them, these large plants grow unchecked, producing millions of long-lived seeds and forming dense stands in which little else will grow.

In response to the problem in Illinois, a team from the Illinois Natural History Survey (INHS) is attacking purple loosestrife using biological control as part of a national program against the weed. Biological control of weeds uses herbivorous natural enemies that normally keep plants in check in their native habitats. Because loosestrife is an exotic perennial that is not closely related to agronomic or threatened native plants, the weed is a perfect candidate for biological control. In the early 1980s, U.S. Fish and Wildlife Service (USFWS) biologists and European biocontrol specialists identified the numerous insect species that feed on (and control) purple loosestrife in its native European habitats. Five beetle species that proved extremely host-specific were sent from Europe to the USFWS lab at Cornell University for further testing, rearing, and broader U. S. distribution.

Taking advantage of this national effort in 1994, Illinois Department of Natural Resources (DNR) biologists and land managers from several Illinois counties purchased beetles from the USFWS program. Seven thousand leaf-feeding chrysomelid beetles, *Galerucella calmariensis* and *G. pusilla*, (at $2 apiece) were released in seven sites in northern Illinois. In 1995, INHS biologists assumed leadership of the Illinois biological control project, in partnership with DNR and county land managers. In June 1995, another 3,000 adult leaf-feeding beetles were released, as well as several hundred eggs of another agent, the root-feeding weevil *Hylobius transversovittatus*.

Adult beetles, eggs, and larvae from the 1994 releases were found at all release sites, indicating successful overwintering. Because of that finding, the program expanded during the winter of 1995-1996, with plans for large-scale releases in 1996. State and county land managers selected 30 threatened, high-quality wetlands needing control measures as release sites. INHS entomologists conducted training sessions for land managers covering beetle biology, release strategies, and plans for monitoring releases. In preparation for mass rearing, approximately 10,000 beetles were cultured and refrigerated to simulate overwintering; after "overwintering," these beetles were caged on over 500 loosestrife plants in the greenhouse to produce the new generation of beetles for release.

The goal was to release at least 2,000 beetles at each of these 30 sites, from mid-May through June when purple loosestrife was actively growing. Production from the refrigerated adults exceeded expectations, with over 170,000 adult *Galerucella* reared and released. Several high-quality sites, such as Brandenburg Bog and Wauconda Bog (both in Lake County), Weingart Road Sedge Meadow (McHenry County), and Ferson Creek Fen (Kane County), received large numbers of beetles. Also, over 600 *Hylobius* eggs were inoculated in plant stems at several of the sites.

Field observations made this spring have shown that beetle populations survived a second winter and are growing. Although the 1996 goal for numbers of beetles released was exceeded, the project is not finished. Successful biological control of purple loosestrife will require all of the available control agents, and it will take years for populations of these natural enemies to develop. Over the next few years, Survey entomologists and state and county cooperators hope to rear and release the available control agents at sites where purple loosestrife occurs throughout Illinois.

The total eradication of purple loosestrife in Illinois or anywhere else in North America is unlikely. However, the goal of our biological control program is to reduce the weed's population to a level low enough that the native plants can regain their competitive edge, and help restore valuable wetland communities in Illinois.

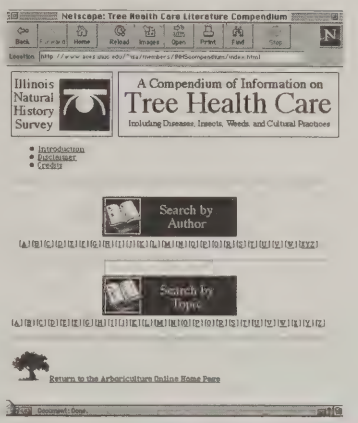
David Voegtlin, Center for Biodiversity, and Robert Wiedenmann, Center for Economic Entomology

Web Collaboration (Arboriculture On-line)

The Illinois Natural History Survey (INHS) has a long tradition of providing unbiased research-based information and resources to the private and public sectors in Illinois. This tradition is continuing to expand to a worldwide audience via the World Wide Web (Web) and the Internet. In order to maintain and update materials that are desired by Illinoisans and others around the world, INHS has developed partnerships with other organizations and agencies to produce publications and other written and visual materials. As we reach the turn of the century, these collaborations are being expanded to encompass electronic media.

In the late 1980s and early 1990s, INHS staff were instrumental in developing the Plant Health Care Management System for professionals in the tree care industries. Plant Health Care Management is an enhancement of the Integrated Pest Management concept that specifically takes into account the variability in client expectations for the quality of ornamental plants and provides a focus on tree health and maintenance. The original publication on the Plant Health Care Management concept, *A Guide to the Plant Health Care Management System*, was funded in part by the U.S. Forest Service and National Arborist Association and was published by the International Society of Arboriculture (ISA). This collaboration paved the way for continued interaction with professional societies devoted to education and researched-based information delivery. As a result of this collaboration, Survey staff were involved in other projects with the ISA including the *Compendium on Tree Health Care*, a complete revision of the original Plant Health Care Guide; the implementation of Plant Health Care workshops; and the development of the *Practitioner's Guide to Plant Health Care*, which will be published in the fall of 1996 with assistance from the University of Illinois, the U.S. Forest Service, and the ISA. In 1995, with the help of INHS staff and the University of Illinois, the ISA became one of the first professional societies to enter cyberspace by developing a "home page" Internet stop on the Web. As the earlier collaborations indicated, this was the beginning of a new realm of cooperation.

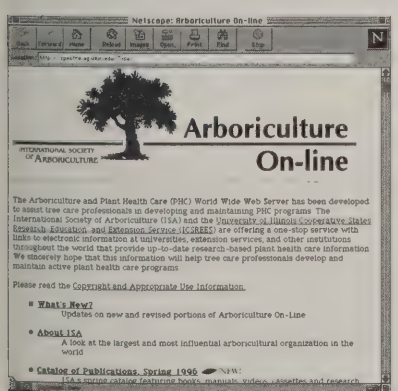
Web technology has created an ideal universe for collaboration among institutions, agencies, and organizations. As the name World Wide Web indicates, with the Internet we can now develop an interconnecting web of electronic links to information available on computers throughout the world. Most academic and research institutions in the world have home pages. With this valuable technology and the resources of the ISA we are able to maintain a continually expanding site called Arboriculture On-line. The address for those with the ability to browse the Web is http://www.ag.uiuc.edu/~isa/. One of the first materials that was redesigned for Web use was the *Compendium on Tree Health Care*. In its printed form, the compendium was awkward to use and was not a popular item for professionals in the tree care industry. However, when it was converted to a database format that was easy to search on the Arboriculture On-line home page, its use skyrocketed. A major portion of the more than 11,000 accesses that are received at the site each month from over 30 countries is devoted to searches of the compendium.



Compendium on Tree Health Care home page.

Our hope for the future is to continue developing educational and research-based materials in collaboration with other agencies, institutions, and organizations and provide access to that information via Arboriculture On-line and the INHS home page (URL: http://www. inhs. uiuc. edu). As the technology becomes more readily available (via cable and digital television), we are sure that both Internet resources will provide a foundation of knowledge and expertise for citizens and professionals in Illinois and beyond.

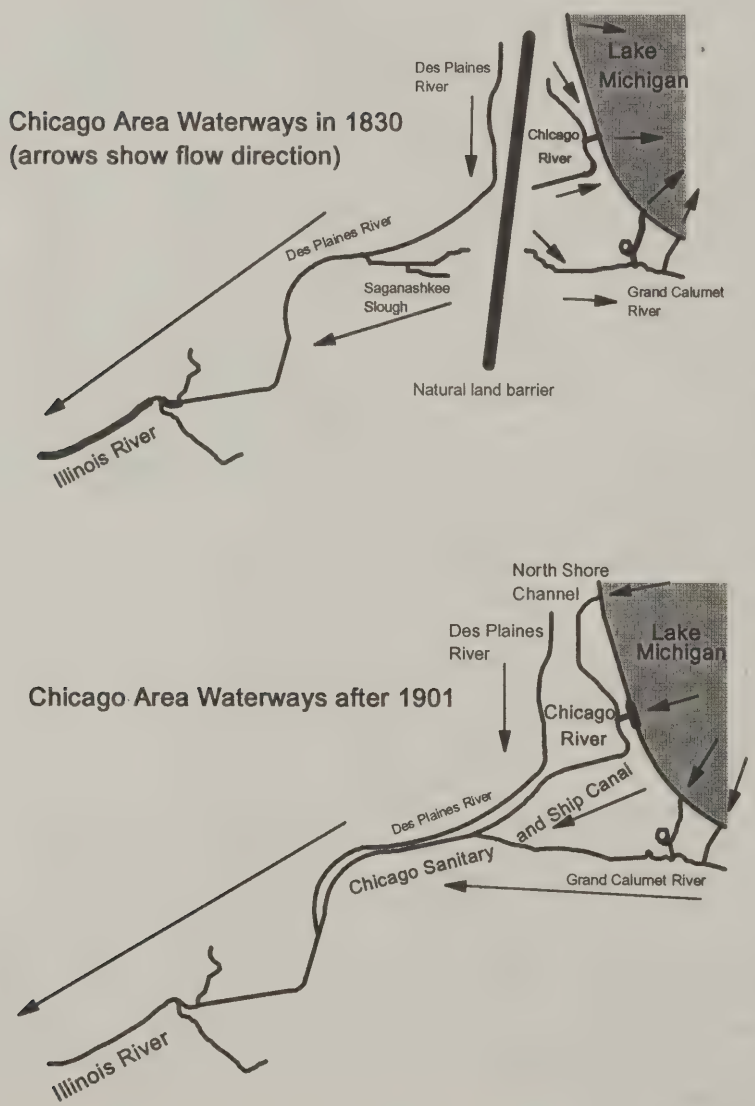
John E. Lloyd, Center for Economic Entomology



Arboriculture On-line home page.

Interbasin Dispersal of Invading Aquatic Species

Exchange of aquatic species between Lake Michigan and the Mississippi drainage basin has probably occurred sporadically for thousands of years. The entire Laurentian Great Lakes Basin was blanketed in the Wisconsin Glaciation more than 14,000 years ago. Following the retreat of the glaciers, vast bodies of water were available for colonization by aquatic species. What we now call the native fish fauna of the Great Lakes Basin originated in large part from the northward dispersal of species from the Mississippi River basin. During the last 14,000 years, Lake Michigan has been periodically connected to, and then isolated from, the Mississippi drainage basin. The last period of natural connection between the two drainage basins ended approximately 6,000 years ago. From then to the early 1900s, the aquatic communities of Lake Michigan and the Mississippi basin developed in relative isolation from each other (although seasonal flooding may have occasionally created small, temporary links between the two systems).



Comparison of Chicago area waterways in 1830 and after 1901 when engineers reversed the flow of the Chicago River.

By the early 1900s, engineers had succeeded in reversing the flow of the Chicago River and completed the construction of the Chicago Sanitary and Ship Canal. The two basins were once again connected by a permanent waterway, allowing large volumes of water to flow continuously from Lake Michigan into the Mississippi drainage basin, and greatly facilitating the exchange of species. This new era of species exchange is of concern to biologists for several reasons. The initial era (about 14,000 years ago) involved species moving from an established basin (Mississippi) into a newly created aquatic system (Lake Michigan) that lacked an established aquatic community. Subsequent eras of species exchange involved species that had at least evolved on the same continent. At present, however, the frequency and ease of modern transoceanic shipping and the intentional transport of organisms for the aquaculture and aquarium industries have resulted in the invasion of organisms that evolved on different continents and in highly varied aquatic communities.

Transfer and establishment of nonindigenous aquatic species are likely to be highly disruptive. Nonindigenous species may be freed from predators and diseases encountered in their native range and exhibit explosive population growth following establishment in a new area. Conversely, they may harbor and introduce new diseases and parasites that native species have not evolved with and have no defenses against. Once an invading species becomes established in either basin, it is not isolated in that basin. Rather, it can rapidly disperse to the other before control and

Continued on next page

New INHS Publications Catalog

The new INHS Publications Catalog is now available at the INHS Distribution Office. You may obtain a copy by contacting the office at:

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607 East Peabody Drive
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Readers who are connected to the World Wide Web may access the new publications catalog at URL: http://www.inhs.uiuc.edu/chf/pub/pub-catalog/spring96/

We have also placed all 1995 and 1996 issues of this newsletter on the Web. They can be accessed at URL: http://www.inhs.uiuc.edu/chf/pub/surveyreports/srindex.html

Look for future on-line INHS publications via our home page at URL: http://www.inhs.uiuc.edu/

Aquatic Invaders

continued from previous page

eradication measures can be developed and implemented. Scientists at INHS field stations along Lake Michigan and the Illinois and Mississippi rivers are actively involved in studying the impacts and transfer rates of invading species within and between the Great Lakes and Mississippi drainage basins.

The zebra mussel (*Dreissena polymorpha*) is a good example of an invading species that became established in Lake Michigan and quickly dispersed into the Illinois and Mississippi rivers. Zebra mussels became established in the Great Lakes in the late 1980s. In 1993, these mussels reached an average abundance of 60,000 / m^2 in the lower Illinois River and were becoming established in the Mississippi and Ohio rivers. Unlike the relatively stable populations in the Great Lakes, zebra mussel populations in the Illinois River exhibit recurrent boom and bust cycles. Periodic high mortality in the Illinois River is presumably due to unfavorable environmental conditions, such as high temperature, high turbidity, or low dissolved oxygen, which persist during low flow periods in the summer months.

Once an invading species successfully moves from one basin to another, the continued success of that species in the new basin may be dependent upon continual dispersal across the interbasin connection. Zebra mussel larvae spawned in a riverine system are quickly carried downstream by river currents. Establishment and maintenance of zebra mussel populations in the main channel of a river are dependent upon the production of new larvae by upriver populations. Estimates of larval growth and drifting rates in the Illinois River indicate that most zebra mussel larvae travel a minimum of 190 miles before settlement. Settlement in the upper 70% of the river is therefore dependent upon larvae produced by populations upriver of the Illinois River headwaters. In this system, the Lake Michigan population may provide a stable, upriver source of larvae. Without the interbasin connection and dispersal of larvae, zebra mussel populations in the river would presumably begin to die off in a downriver direction as their sources of new recruits were eliminated.

Other invading species that are now found in both basins include the white perch (*Morone americana*) and the rudd (*Scardinius erythrophthalmus*). Many other invading species may be poised for interbasin dispersal in the near future. The round goby (*Neogobius melanostomus*), tubenose goby (*Proterorhinus marmoratus*), and the ruffe (*Gymnocephalus cernuus*) are three fish species that have become established in the Great Lakes within the past several years. They are expected to have significant, detrimental impacts on several native fish species and may soon appear in the Illinois and Mississippi rivers. The grass carp (*Ctenopharyngodon idella*) and bighead carp (*Hypophthalmichthys nobilis*) have recently established breeding populations in the Mississippi and Illinois rivers and may soon disperse into the Great Lakes. The striped mullet (*Mugil cephalus*) is occasionally collected from the Mississippi drainage basin. An invading zooplankter (*Daphnia lumholtzi*), recently established in Illinois, was found last year in the Illinois River just 100 miles

Photo by LTRMP staff at La Grange Reach in Havana

INHS researcher Scott Whitney studies the effects of zebra mussels - on native unionids in the Illinois River.

continued on back page

Species Spotlight

Bobcats

Susan Post

The bobcat, once a relatively abundant contemporary of the bison and elk, is the smallest native member of the cat family in North America. Known to early settlers and travelers of Illinois as wildcat, short-tailed wildcat, bay lynx, and catamount, bobcats were a formidable enemy of the settlers' free-ranging sows and piglets. In early Illinois the bobcat was common and high up on the food chain. When widespread in Illinois, the bobcat was most often found in counties with heavy timber stands or along major waterways. Today, this endangered species is most likely encountered in the wooded regions of the northwestern and southern counties. Its inherent caution and tendency to "mind its own business" have enabled it to persist in some agricultural regions, as long as tracts of suitable woodland habitat remain.

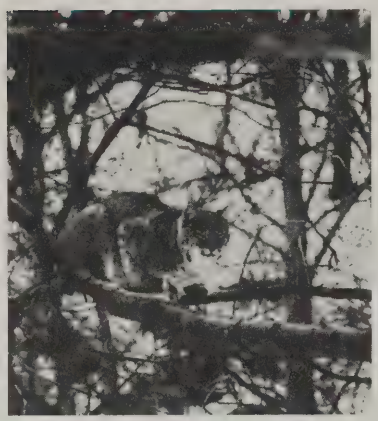


Photo by Michael Jeffords, INHS Center for Economic Entomology

Bobcat (Lynx rufus) *resting in tree.*

At first glance the bobcat may appear to be a timid creature, running at the slightest provocation. In reality, a bobcat will invariably detect the approach of any invader, quietly leave its resting place, and silently retreat without ever being seen or heard. When cornered or attacked by enemies, though, it becomes a different creature—a wild, slashing demon of unlimited courage. It screams, growls, spits, hisses, and tries to scratch out the eyes and every other part of an enemy's anatomy.

Bobcats usually weigh less than 25 pounds. The color and weight of their coats are somewhat dependent on where the animals dwell, what they eat, and their ages. To the rabbits, squirrels, mice, and other small game on which they feed, bobcats are a persistent and remorseless enemy. To locate prey bobcats use their acute vision and hearing. Large feet enable them to prowl softly through the night while hunting for food; cryptic coloration helps them blend with their surroundings. An old myth claims that a bobcat will hide in dense cover and attract game by rapidly twitching its tail. This is not true; on average, the animal covers two to seven miles in an evening while looking for food.

One of the few times a bobcat may be heard is in early winter. The males begin to squall and yowl to capture the attention of a passing female. After a successful serenade (usually from January to late February) bobcats mate, and following a gestation period of about 50 days, the female gives birth to one to four kittens. Bobcat kittens do not open their eyes until they are nine days old. Born unskilled in the art of hunting, kittens can learn to kill their own food when the mother bobcat brings live prey to the den. The female keeps them with her through early autumn until their education in the ways of the bobcat is complete.

The last thing on a bobcat's mind is to become entangled with people. They are so successful at keeping out of sight that few humans are ever aware of their presence. Even those who do catch a quick glimpse often aren't sure whether they have seen a real bobcat, a stub-tailed version of a house cat, or an apparition—a phantom of the forest.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Going Around in Circles

Objective: to investigate the differences and similarities between various organisms

Materials: multiple copies of **Going Around In Circles**

Vocabulary: Venn diagrams

Comments: Venn diagrams were the brainchild of Englishman and mathematician John Venn during the last century. In simple terms, Venn diagrams use overlapping circles to show relationships between different things. In this edition of the *Naturalist's Apprentice*, we will use simple Venn diagrams to explore the differences between pairs of organisms and to graphically organize that information and decide who is more closely related to whom.

Procedure:

1. Introduce and explain the concept of a Venn diagram to your students.

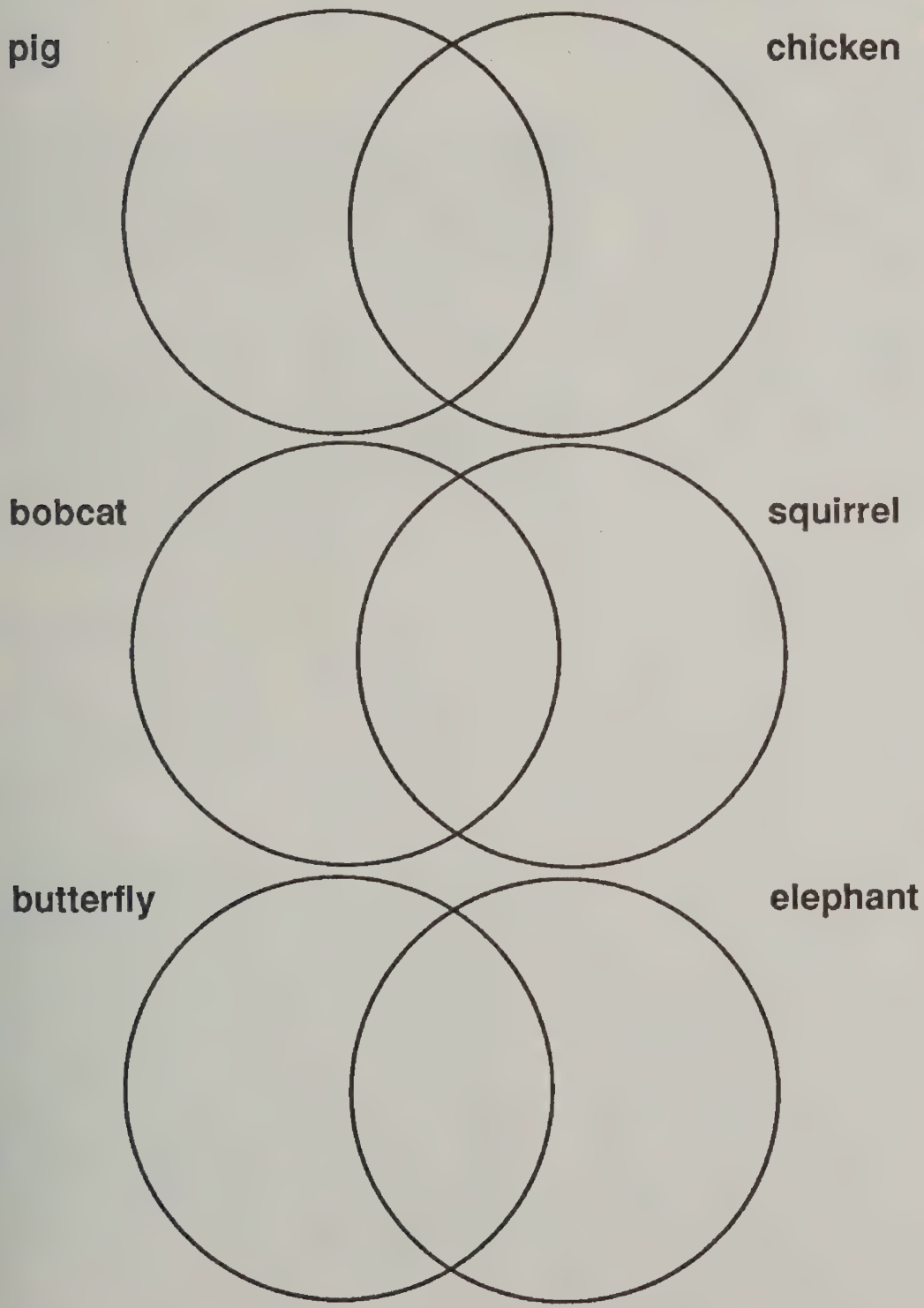
2. Distribute copies of **Going Around In Circles** and have students list characteristics of each organism. Those traits that are different should be placed in the parts of the circles that do not overlap. Those traits that are shared by both organisms should be placed in the overlapping portions of the circles. Students should try to use as many traits as they can think of or for which they can find information.

3. Students now decide which of the three pairs are most closely related to each other.

Going Around In Circles

Study each of the pairs of organisms and list characteristics that make those organisms different from each other (e.g., three toes vs. two toes). Write those in the unshared parts of the circles. Next, list characteristics that both organisms share with each other (e.g., both have fur). Write those in the shared portions of the circles.

Complete all three pairs and decide, based on these diagrams and the characteristics you chose, which pairs of organisms are most closely related to each other.



ILLINOIS
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Elk

continued from front page

poor habitat because they are too small.

Given these criteria, our analysis indicated that, not surprisingly, the best prospects for reintroducing elk are in the regions surrounding the Shawnee National Forest. Comparisons of areas in the Shawnee suggested that the eastern side (Pope County) may be a more suitable area for elk due to lower road density, less agriculture, less urban area, and more diverse forest cover-types.

Our analysis also indicated two important challenges to elk restoration. First, while the Shawnee is among the least developed areas in Illinois, it still has higher road densities than most western elk habitat; thus, human disturbance may be a problem. Second, in spite of having large areas of natural or seminatural vegetation, many small farms, nurseries, and orchards are located in and around the Shawnee. Crops, nursery stock, and fruit trees would be vulnerable to elk depredation should elk be reintroduced.

Photo by Tim Van Deelen, INHS Center for Wildlife Ecology

Herd of elk cows and calves at Yellowstone National Park.

DNR is continuing to study the feasibility of reintroducing elk and is currently assessing potential economic and social impacts. Will visitors to southern Illinois be able to see elk in the near future? Stay tuned...

Timothy R. Van Deelen, Center for Wildlife Ecology

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Aquatic Invaders

continued from page 5

River just 100 miles downstream of Chicago. *Daphnia lumholtzi* adults and ephippia (resting eggs) could easily be transported from the Illinois River into Lake Michigan via bilge water and live wells of recreational watercraft.

Interbasin dispersal does not necessarily mean that an invading species will establish viable populations in both basins. While some species may adapt to environmental conditions in both Lake Michigan and the Mississippi drainage basin, others may not. Unfortunately, the relative ease of interbasin dispersal means that those invading organisms that are capable of surviving in both environments may colonize both basins before adequate studies of ecological impacts and control techniques can be conducted. The Lake Michigan-Mississippi interbasin connection is primarily man-made and highly engineered. It may be possible in a system such as this to construct dispersal barriers which would reduce or eliminate the interbasin dispersal of some invading species. Survey scientists are now planning to conduct studies to document the extent of interbasin dispersal and the feasibility of constructing dispersal barriers.

Jim A. Stoeckel, Richard E. Sparks, K.D. Blodgett, Scott D. Whitney, and Paul T. Raibley, Center for Aquatic Ecology

ILLINOIS NATURAL HISTORY SURVEY

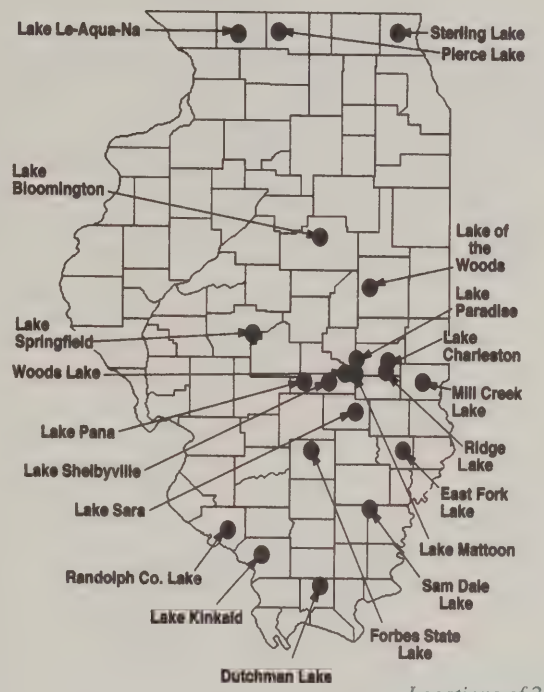
Reports

November/
December 1996
No. 342

INSIDE

Critical Factors in the Early Life History of Illinois Fishes

Fish communities in Illinois reservoirs can be influenced by changes in environmental conditions throughout the year. Within these fish communities, larval or young fishes are often the most susceptible to these fluctuations in abiotic and biotic conditions. During the critical early life stage of fish, slight changes in the environment can drastically affect the recruitment of young fish into the adult population. In fact, of the vast number of larvae that hatch, only a small percentage actually reaches the juvenile or adult stage. Even though biologists have recognized the importance of identifying the factors influencing recruitment, most studies have only dealt with a single lake or reservoir system. As a result, environmental variation is minimized due to restrictions of space and time. Our study was designed to examine several abiotic and biotic factors thought to determine larval fish growth rates across a series of Illinois reservoirs.



Locations of 21 Illinois reservoirs that were sampled to encompass range of limnological and morphological characteristics.

We sampled 21 reservoirs (see map) every other week from May through July 1995. On each date, we collected larval fish and zooplankton samples and measured temperature, dissolved oxygen, and secchi disk depth. Lake morphometrics and water chemistry data were obtained from previous lake surveys. Principal Components Analysis (PCA) was used to reduce the large number of variables to a smaller set of factors. The PCA scores were then correlated to larval fish growth rates for each reservoir.

The most abundant larval fish species across reservoirs were gizzard shad (*Dorosoma cepedianum*), sunfish (*Lepomis* spp.), crappie (*Pomoxis* spp.), and brook silversides (*Labidesthes sicculus*). The peak densities of these young fish varied greatly across reservoirs and ranged from 1 to 250 fish per liter. Zooplankton levels (the major food source for young fish) showed similar high variation across reservoirs and through time.

The first principal component (PC 1) is composed of mean depth, shoreline length, and the

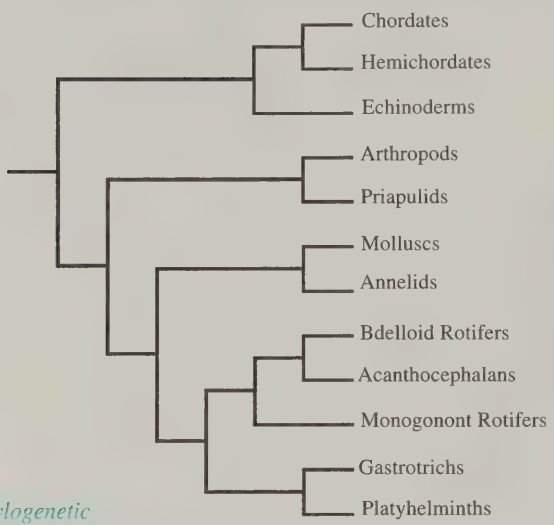
Continued on back page

Otolith bone in larval fish used to determine age and growth.

Photo by Randall Claramunt, INHS Center for Aquatic Ecology

Acanthocephalans and Rotifers Provide Clues for Study of the Evolution of Animal Parasites

The success enjoyed by animal parasites is expressed in the independent evolution of parasitism in nearly every phylum of animals.



Phylogenetic hypothesis of animal phyla resulting from analysis of nuclear DNA sequences.

Many of these animal parasites are helminths, more commonly referred to as worms. The phyla Platyhelminthes (flatworms), Nematoda (roundworms), and Arthropoda (referring specifically to tongue worms) contain both free-living and obligately parasitic species. The formerly recognized phylum Acanthocephala contains only obligate parasites. These groups have been studied in order to examine the evolution of parasitism in animals. Hypotheses concerning the evolution of parasites have been developed through comparisons of related parasitic and free-living organisms. More recently, these comparisons have utilized phylogenetic methods, which attempt to uncover true evolutionary relationships among organisms.

The phylogenetic method groups related organisms by the presence of shared derived characters, referred to as synapomorphies. The resulting hypothesis of evolutionary relationship is termed a phylogeny. The development of phylogenetic hypotheses of parasitic helminths and their free-living relatives has been hampered by the large number of species in particular groups, and extreme morphological and ecological diversification, which severely limit the number of characters available for a phylogenetic analysis.

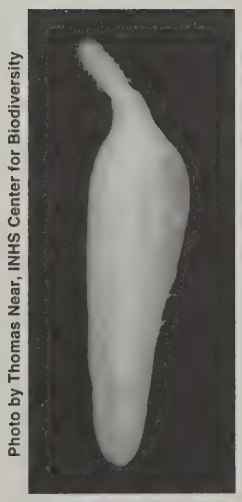


Photo by Thomas Near, INHS Center for Biodiversity

Echinorhynchus salmoides *collected from an introduced rainbow trout in Lake Michigan.*

Scientists at the Illinois Natural History Survey, in collaboration with scientists at the University of California-Davis and Duquesne University, have been examining the phylogenetic relationships of the Acanthocephala, a fascinating group of obligately parasitic helminths. The characters used to construct the phylogenetic hypotheses of the Acanthocephala are DNA sequence data from the nuclear genome. In addition, nuclear DNA sequences were collected from many other animal phyla in order to determine the evolutionary origin of the Acanthocephala.

The Acanthocephala have long been regarded as an independent phylum of approximately 850 species, all of which display complex life cycles. As larvae, acanthocephalans are obligate parasities of arthropods; as sexually mature adults, they parasitize vertebrates, residing in the alimentary tract of the host. Determining the phylogenetic relations of the Acanthocephala to other animal phyla has been enigmatic owing to the extreme adaptations to its parasitic mode. The word acanthocephala means "thorny head" and refers to the ubiquitous presence of a retractable proboscis armed with recurved hooks. This proboscis allows the acanthocephalan to adhere to the intestinal wall of the vertebrate host. All acanthocephalans lack a mouth and a gut, possessing instead a specialized tegument to absorb nutrients from food material passing through the host intestine. Superficially, the Acanthocephala resemble another group of obligately parasitic helminths, the cestodes (tapeworms). However, features common to both acanthocephalans and cestodes, a hooked head region and lack of digestive tract, are hypothesized to be a result of independent evolution within these two groups.

Phylogenetic analysis of nuclear DNA sequence data from 15 animal phyla, including the Acanthocephala, revealed a very surprising relationship. All analyses produce a phylogenetic hypothesis that places the Acanthocephala *within* the Rotifera. In other words, some rotifers are more closely related to acanthocephalans than they are to other rotifers. The conclusion from this relationship is that the Acanthocephala appear to have evolved from free-living rotifers. This result is supported by the presence of unique morphological similarities in the two groups. Both rotifers and acanthocephalans possess a syncytial epidermis (not differentiated into cells), a unique skeletal lamina, and flagellum in the anterior position on sperm cells.

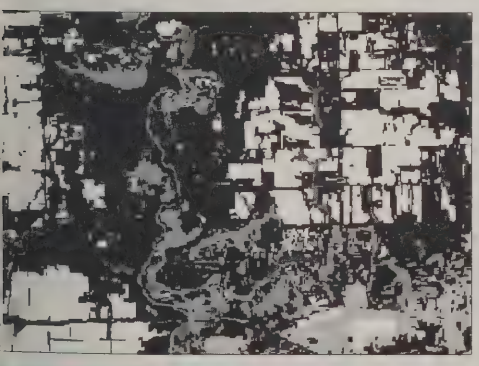
The result of this investigation represents the first time that a free-living nearest relative of a parasitic helminth group has been identified. With this elucidated relationship, the "acanth research group" at the Natural History Survey will revise higher-level classifications (placing the Acanthocephala into the phylum Rotifera), examine the adaptive evolution of the Acanthocephala, examine further homology between acanthocephalan and rotifer morphological features, test hypotheses concerning the evolution of parasitism in the Acanthocephala, and examine obligately parasitic rotifers to determine if they represent the nearest relative of the Acanthocephala.

Thomas J. Near, Center for Biodiversity

A Land Cover Map of Illinois

A land cover database for all of Illinois was recently completed by researchers at the Natural History Survey as part of the Critical Trends Assessment Project. The Land Cover Database of Illinois represents the most current and comprehensive inventory of the state's surface cover. It is available on CD-ROM to support the ecosystem watch programs of the Illinois Department of Natural Resources (DNR) and is also included on DNR's second release of digital spatial datasets on CD-ROM. This database provides a much needed baseline for evaluating environmental change, supports research, and supports efforts to educate the public.

Satellite data, image-processing software, existing spatial digital databases, and aerial photography were used to classify and map the surface cover of the state's 36 million acres. The Landsat Thematic Mapper satellite collects spectral information for each 28.5 x 28.5-meter piece of the earth, creating a pixel. The distinct spectral value for each of Illinois' nearly 300 million pixels was used to classify them into 1 of 19 land cover classes. The resulting database can be used with the wealth of existing digital information technology and geographic information systems (GIS) to produce maps, perform analysis, and assess change.



...re 1. Middle Fork of the Vermilion ...west of Danville. Predominant cover ...s (dark to light) include woodland, grassland, water, and cropland.

To improve discrimination and coding, two dates of satellite imagery were used. The vegetation changes that occur throughout the year are detected in the satellite data and the use of two dates exploits these phenological differences. To further improve classification, urban areas and small towns were analyzed separately from the non-urban landscapes. Crop compliance data from the Natural Resources Conservation Service were essential in discriminating the homogeneous but spectrally diverse agricultural landscape. Color infrared photography was manually interpreted to help classify the satellite data into distinct land cover categories, such as deciduous woodland, water, high density urban, and so on.

The land cover database and map are spatially complex, reflecting the fragmented character of Illinois' landscape. Features such as railroad corridors, greenways, airport runways, commercial strips, and small wood lots are discernible (Figure 1). The size and complexity of the data often require further processing to facilitate analysis. For an inventory of resource-rich areas in Illinois, recently completed at the Survey, the data were aggregated. The percentage of woods and wetlands in each of 816 watersheds was determined from the land cover data. This information was used in conjunction with the acreage of natural areas and occurrence of biologically significant streams to identify the sites depicted in Figure 2. These sites cover less than 20% of the state but they contain one-third of the state's woodlands and nearly half of its wetlands.

To identify potential habitat for the reintroduction of elk in southern Illinois (see the September/October 1996 issue of *Illinois Natural History Survey Reports*) these data were recoded and spatially aggregated. Each cover type was coded to reflect its value as habitat and cover for elk. The data were then averaged to a spatial resolution of 1 hectare.

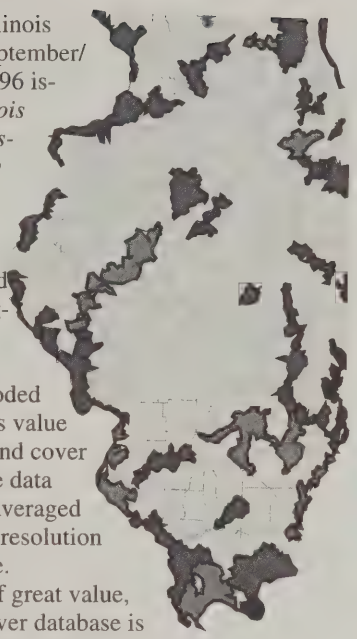


Figure 2. Resource-rich areas identified by INHS researchers.

While of great value, the land cover database is but a point on a continuum. With funding from the national Gap Analysis Program (GAP), work is under way to further discriminate natural vegetation. This program seeks to reclassify the land cover database at a resolution that identifies plant communities and alliances. GAP will also map the current distribution of all land vertebrates in Illinois and model habitat suitability.

As data from across the state are integrated, information will increasingly support both regional and local efforts. These efforts will allow biologists or land managers to utilize site-specific data to perform landscape analyses, evaluate ecosystems and watersheds, determine population distribution and dispersal, and quantify habitat fragmentation. Spatially integrated data are critical to the continued understanding and management of the state's natural resources. Continued refinement of the land cover and other databases expands our ability to better understand the nature of Illinois.

Mark Joselyn, Liane Suloway, and Tony McKinney, Center for Wildlife Ecology

IN MEMORIAM
Dr. Warren Ulrich Brigham

Warren Brigham, aquatic coleopterist, Professional Scientist, and long-time employee of the Illinois Natural History Survey, passed away on August 7, 1996; he was 54.

Warren's interest in aquatic biology was sparked at an early age; by 7th grade his insect collection already was extensive. By the time he graduated from high school, Warren had conducted surveys for fishes using rotenone and block netting, measured water quality parameters, and documented the morphometry of a lake in Wisconsin where his family had a summer cottage.

Photo by Mark Wetzel, INHS Center for Biodiversity

Warren Brigham on an aquatic insect collecting trip in Missouri in 1991.

Warren joined the Survey in 1961 as a project assistant. He earned his B.S. degree in zoology from the University of Illinois in 1964. After a two-year period at Tennessee Technical University, where he earned an M.S. degree in zoology and botany, he returned to Champaign to enroll in a doctoral program at the University of Illinois and continue employment as a research assistant in the Section of Aquatic Biology at the Survey. From 1969 through 1972, Warren was the resident biologist at the Survey's Sullivan Field Lab at Lake Shelbyville. Upon completion of his Ph.D. in zoology and civil engineering from the University of Illinois in 1972, he returned to the Survey offices in Champaign, continuing his career as an aquatic biologist. Warren was promoted to Assistant Professional Scientist in 1972, to Associate Professional Scientist in 1976, and to Professional Scientist in 1983. He served as Director of the Center for Biogeographic Information from 1989 through 1992, as Manager of the Illinois Geographic Information System from 1982 through 1992, and most recently as a Professional Scientist in the Office of the Chief of the Survey.

Warren was largely responsible for introducing geographic information systems (GIS) technology to the former Illinois Department of Energy and Natural Resources and to the state of Illinois. He became interested in GIS in the formative stages of the technology, and this led to the establishment of the Illinois Geographic Information System (IGIS). Warren's enthusiasm for GIS made him one of the premier advocates for GIS across the country and around the world. Under Warren's guidance, the IGIS became a critical resource for researchers working to inventory and analyze the state's natural resources.

Warren's professional accomplishments included authorship or co-authorship of 21 peer-reviewed publications on fishes, aquatic insects, and GIS technology; editor and principal author on the distribution, life histories, and environmental requirements of the aquatic insects of North and South Carolina; co-authorship of the aquatic Coleoptera chapter in the 2nd and 3rd editions of a principal textbook on aquatic entomology for North America; principal or co-investigator on numerous grants and contracts; consultant and principal investigator on GIS, remote sensing, and database management for the U.S. Agency for International Development, which he assisted in establishing GIS and training of staff in Kenya, and in the design of spatial data components for the National Biodiversity Support Program in Indonesia; technical expert on GIS and data management for the National Biodiversity Information Center, Smithsonian Institution, and National Biological Survey; and membership on the Computerization and Networking Committee for the Association of Systematics Collections. In addition, Warren served as a reviewer of proposals, consultant on GIS and database management, and Biological Facilities Panelist for the National Science Foundation.

Warren's memberships in professional organizations included the American Fisheries Society, American Society of Ichthyologists and Herpetologists, American Society of Limnology and Oceanography, Coleopterists Society, Ecological Society of America, Entomological Society of Washington, Kansas (Central States) Entomological Society, North American Benthological Society (NABS), and Societas Internationalis Limnologiae. His involvement in NABS was extensive; he had been a member of the NABS Literature Review Committee since 1971, and had served as program chair, member of the Executive Committee, and member of the Committee on Com-

Continued on page 6

Microbial Larvicides in Mosquito Control

The next time you are scratching a mosquito bite, it may comfort you to know that mosquitoes have their problems too. Although mosquitoes can transmit human and animal diseases in Illinois, such as St. Louis encephalitis, LaCrosse encephalitis, and canine heartworm, there are many bacteria, protozoa, and fungi that infect mosquitoes in turn. Microorganisms that infect mosquitoes and other insects are known as entomopathogens to distinguish them from vertebrate pathogens such as the influenza virus. The most widely used entomopathogens in mosquito control are commercially produced bacteria. Larvicides containing these bacteria are harmless to beneficial insects and animals, but can rapidly kill susceptible larvae, which are the immature stages of the mosquito that live in water. Until recently, all bacterial larvicides targeted against mosquitoes contained the bacterium *Bacillus thuringiensis serovar israelensis*, but more recently a new product containing the bacterium *Bacillus sphaericus* strain 2362 has become available. As mosquito species become resistant to the chemical larvicides currently available, and people become increasingly concerned about the impact of chemicals on the environment, interest in the use of bacterial larvicides as alternative control agents for mosquitoes has increased.

One of the primary activities of the Survey's Medical Entomology Program has been the investigation of methods to control mosquito larvae in used tires. Used tires pose a unique problem for mosquito control because they do an excellent job of holding water. Over 10 million used tires are discarded in Illinois each year, and a single tire can produce as many as 1,000 adult mosquitoes. One species of woodland mosquito, *Aedes triseriatus*, breeds in treeholes and tire piles throughout Illinois, and transmits the virus that causes the human disease LaCrosse encephalitis.

Three other species of mosquitoes that use tires as larval habitat—*Culex restuans*, *Culex pipiens*, and *Culex quinquefasciatus*—transmit the virus that causes St. Louis encephalitis in man. Also, waste tires serve as home for a new invader, *Aedes albopictus* (Asian tiger mosquito), which can also transmit several viruses to man.

The Medical Entomology Program has conducted numerous studies evaluating methods to apply larvicides in an environmentally friendly manner. Thanks in part to research conducted by this program, all manufacturers have adopted corncob granules as carriers for larvicides. These granules break down rapidly in the environment, and their use provides an additional market for corn products. Currently, in collaboration with Abbott Laboratories, an Illinois-based company, we are evaluating the efficacy of a new larvicide, Vectolex®, which contains the bacterium *Bacillus sphaericus* strain 2362. This past summer we evaluated this product's effectiveness in controlling mosquitoes in tires, and have also investigated its potential in urban environments. Preliminary data indicate that this product provided excellent control when applied to tires containing *Aedes triseriatus*, *Culex restuans*, and *Culex pipiens* larvae. Within the city, *Bacillus sphaericus* controlled *Culex restuans* and *Culex pipiens* larvae in catch basins. If our results are confirmed, this bacterium will become an alternative to the chemicals currently used to treat catch basins.

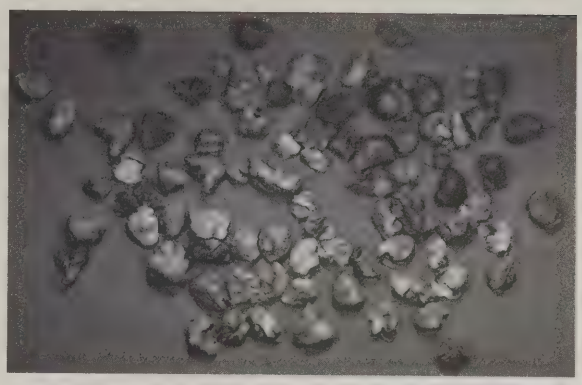


Photo by Joel Siegel, INHS Center for Economic Entomology

Corn granules coated with bacterial larvicide.

In addition to these applied studies, we are also investigating the use of a new technology, cellular fatty acid analysis, to "fingerprint" commercially produced larvicides. This research is being done in collaboration with Dr. A. Ray Smith at the UIUC College of Veterinary Medicine. These fingerprints will enable us to determine the length of time that a single treatment persists in tires, as well as evaluate the impact of microbial larvicides in sensitive wetland habitats. Recent studies conducted in the field indicate that microbial larvicides can persist for as long as one year in used tires, and in some instances, recycle in tires as well. This last point is important because it raises the possibility that a single treatment may not only last one summer but carry over into the next year.

Joel P. Siegel and Robert J. Novak,
Center for Economic Entomology

Species Spotlight

Eastern Box Turtles

Susan Post

Nothing on earth is like a turtle. Other animals have shells—snails and clams, crayfish and lobsters—but they have either fewer or more than four feet. In Illinois, one of the more common turtles is the eastern box turtle, found in the southern half of the state and usually seen crossing the road or rustling through the leaves in the woods. The natural distribution of this turtle corresponds to the last glacier. Eastern box turtles are found south of a line where the Wisconsinan glacier stopped.

Photo by Michael Jeffords, INHS Center for Economic Entomology

Eastern box turtles. Terrapene carolina carolina.

One of the unique features of turtles is their shell. Both halves are solidly fused, so they cannot leave it behind, (this happens only in cartoons!). The shell is divided into two halves—the carapace, or upper section, and the plastron, or lower section. Plates cover the carapace and plastron and give the turtle its color and design. In box turtles, this is a radiating pattern of light yellow to orange lines or spots on a background of dark brown. Box turtles have a high dome-shaped shell with a movable plastron that has a hinged seam. This allows the turtle not only to retreat inside its shell but also to swing the bottom portion of the plastron tight against the carapace so no soft parts are exposed.

Although eastern box turtles belong to the largest family of turtles in the world, the Emydidae (pond-and marsh-inhabiting, semiaquatic turtles), permanent water does not seem to be a requirement for them. The eastern box turtle commonly resides in open woodlands—areas with large trees, canopy gaps, and a diversified ground cover. Box turtles are active during the daylight hours, basking at openings in the canopy and traveling to find food. When they are not seeking food, they rest in forms, depressions made in the vegetation and top inch of soil. The turtle will remain in the form until the morning sun warms it up. The form insulates the turtle's belly plate (plastron) during hot days and cool nights.

Eastern box turtles may meander up to 70 yards per day while foraging for food. Since turtles have no teeth, they must use the strong, sharp edges of their jaws, which form a beak, to eat their preferred foods of fungi, fruits, and small invertebrates.

Most box turtles have home ranges, and those that are encountered crossing the road are usually transients. Of these transients, half are youngsters, both male and female, and less than nine years old. The other half is composed of adult males. The transients move only one way through the environment, with no turning back. So remember, the next time you rescue a turtle from the road, note the direction it was going and help it along in the right direction!

The eastern box turtle's annual cycle begins in early April when it emerges from hibernation. Turtles will mate from May through October. Sexual maturity is related to the size of the carapace, not age. Turtles are fully mature when their shell length is eight inches long. After a courtship, which involves circling, biting, and shoving, the pair will mate. The female is able to produce fertilized eggs up to four years after a single mating. When she is ready to lay eggs, she will dig a nest three to four inches deep with her hind feet. Three to eight elliptically shaped eggs are laid in the depression. The female then repacks the nest. The eggs will hatch in two to three months.

When autumn night temperatures drop to the mid-forties, box turtles begin to look for a place to spend the winter. Each day the turtles will dig a short distance into the soil and by the first freeze they are usually deep enough to be protected. They do not hibernate below the frost line, but remain dormant at depths down to five inches below the leaf litter.

Warren Brigham

continued from page 4

mon and Scientific Names of Aquatic Invertebrates.

Throughout his career, Warren's systematic interest and love for aquatic biology focused on aquatic beetles, especially the Haliplidae, or crawling water beetles; he was perhaps the world's foremost expert with that family. Other systematic interests included Megaloptera, Odonata, and scarab beetles. Tantamount to these systematic interests was the daily review of past and present literature discussing every aspect of the Coleoptera. His compilation of the aquatic Coleoptera section of the NABS bibliography for over 25 years—and his desire to share that information with others, most recently on the World Wide Web—is perhaps his single most important contribution to the scientific community.

Warren was unselfish in his leadership, and with his guidance, advice, knowledge, and insight. His friendship was always warm and sincere, and it endured through times of personal and professional differences. His legacy—one that he practiced more than verbalized—is for us to freely share knowledge and information so others might improve in their expertise, be enlightened to new opportunities, and contribute to basic science worldwide.

Warren is survived by his wife, Aleta; daughters Sarah Holt and Cynthia Brigham; a brother, Warner Brigham; and his parents, Rosemary and Charles Brigham.

An endowment fund has been established in his memory to support network integration of research on aquatic Coleoptera. For more information on this endowment fund, please contact Suzanne J. Voegtlin, Illinois Natural History Survey, 172 Natural Resources Building, 607 E. Peabody Dr., Champaign IL 61820; (217) 244-2110; email: suev@mail.inhs.uiuc.edu

Mark Wetzel, Center for Biodiversity

Dr. Lorin I. Nevling, INHS Chief, to Retire

At the Board of Natural Resources and Conservation meeting on August 30, Dr. Lorin I. Nevling, Chief of the Illinois Natural History Survey and Acting Chief of the Illinois State Water Survey, announced that he will retire as of December 31, 1996. Dr. Nevling has served as Chief of the Natural History Survey since 1987 and as Acting Chief of the State Water Survey since November 3, 1996. He previously served as a Member of the Board of Natural Resources and Conservation from 1979-1986.

Dr. Nevling is known as a scientist, an administrator, a counselor, and a public servant. He has made contributions as a scientist to the systematics of higher plants, especially the family Thymelaeaceae, and has served in many capacities to the national botanical community. He served on the Association of Systematics Collections Board for over a decade and recently was awarded the ASC's Association Award for Service. In his career as a scientific administrator at the Herbaria of Harvard University, the Field Museum in Chicago, and the Illinois Natural History Survey, he has shown strong leadership and has retained a sense of focus on the big picture of research organizations for the future.

He provided guidance to the Surveys during the reorganization of the environmental agencies in state government and has led both the Natural History Survey and the Water Survey under the Department of Natural Resources.

Nationally, Dr. Nevling served as a member of the Committee on the Formation of the National Biological Survey (Service), National Research Council in 1993 and has served on committees of several federal agencies. Dr. Nevling has also been active on the state level, serving on various committees in the Department of Natural Resources, the Interagency Committee on Pesticides, and the Governor's Science Advisory Council. In addition, he has served on various committees at the University of Illinois.

Photo from INHS image archives

Brent Manning, Chair of the Board of Natural Resources and Conservation (BNRC) and Director of the Illinois Department of Natural Resources (DNR), has appointed a Board search committee consisting of Dr. Richard Alkire (Chair), Dr. Robert Metcalf, Mr. Allan Mickelson, and Dr. John Yopp. An internal Survey search committee will also be formed. The two search committees will work together under the coordination of Director Karen A. Witter, Office of Scientific Research and Analysis, DNR, to recommend a candidate for the position of chief. The appointment will be made by the BNRC. The Natural History Survey and the other Surveys/Center are divisions of the DNR Office of Scientific Research and Analysis.

Mary Krzysik, Office of the Chief

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Critical Factors

continued from front page

surface area of the reservoir. These variables accounted for the most variation among the reservoirs but did not correlate with growth rates of any larval fish species. Lake size, then, did not influence larval fish growth rates in any way.

The next component was described by zooplankton abundance and secchi disk depth (PCA 2). The correlation between the two variables supports the previously identified relationship between zooplankton dynamics and water clarity. The explanation is that an increase in light penetration results in an increase in algae, providing more food for more zooplankton. Since zooplankton are the primary food source during the early life of most fishes, we expected to find that this component (PC 2) would influence growth for all species; however, this was not the case.

Gizzard shad growth rates were not correlated with zooplankton or turbidity (PC 2). In fact, the only environmental factors that slightly correlated with shad growth rates were temperature and latitude, the next component (PC 3). These variables also showed a similar weak correlation with growth rates for other species. Larval fishes in northern Illinois reservoirs grew slower than fishes in southern Illinois reservoirs likely due to temperature influences. Unlike shad, important factors in determining growth rates of other larval fishes were zooplankton, turbidity, and total larval fish densities.

Our study identified important factors influencing the growth rates of larval fishes and provides predictions regarding fish growth and success across lakes and reservoirs in Illinois. Gizzard shad was the only species not influenced by environmental factors, and may potentially explain why this species can pose overwhelming population problems in our lakes and reservoirs. In fact, larval gizzard shad are usually abundant and reach large sizes quickly, which is an argument for not using shad as a forage for native game fishes. In addition, the introduction of this fast-growing species may also have adverse effects on the growth of young native fish species. Future work will investigate the possibility that an early diet shift from zooplankton to detritus (organic matter) allows shad to grow independently of environmental influences.

Randall Claramunt and David H. Wahl, Center for Aquatic Ecology

Illinois Natural History Survey Reports is published bimonthly by the Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820. Headquartered on the campus of the University of Illinois at Urbana-Champaign, the Survey is a division of the Illinois Department of Natural Resources.

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ILLINOIS NATURAL HISTORY SURVEY

Reports

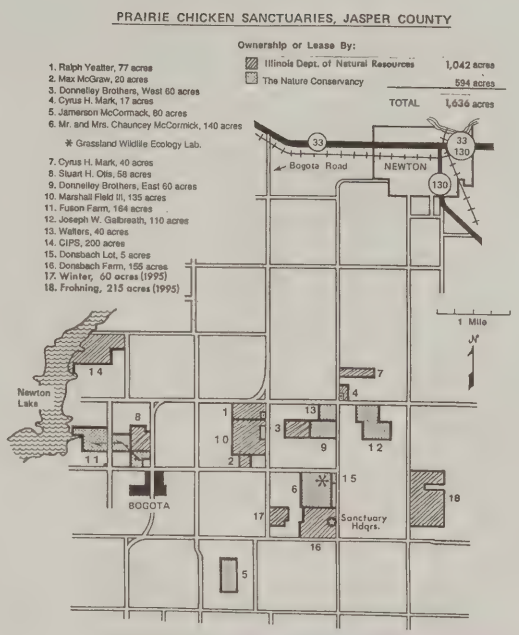
January/
February 1997
No. 343

INSIDE

Grassland for Prairie Chickens: How Much is Enough?

The first of scattered sanctuaries for prairie chickens were acquired with extremely limited funds in the early 1960s by the Prairie Chicken Foundation of Illinois and The Nature Conservancy. Little information was available on the amount of grassland that would be required to preserve the species in Illinois. Also, estimates of the number of individuals of a species that constitute a minimum viable population ranged from 50 to 500; the latter allowed for evolutionary processes to continue over the long term.

Initial goals called for 1,000 acres in each of two counties (Jasper and Marion) to develop and maintain two breeding populations of about 500 birds from extant remnant flocks. A sex ratio of approximately 50:50 was assumed. These goals were believed to be realistic because prairie chicken numbers soared from about 80 to 400 (40-206 cocks) between the mid-1960s and early 1970s in Jasper County. This dramatic response occurred with only 660 acres of sanctuary grassland available to the birds by spring 1972. Nevertheless, the sanctuary goals were raised to 1,500 acres in each of two counties in 1973 to allow for probable intensification in farming practices.



Prairie chicken sanctuaries in Jasper County, Illinois

By spring 1982, a similar encouraging response occurred in Marion County with an increase to about 230 prairie chickens (116 cocks) with only 450 acres of sanctuary grassland. For 19-year periods, densities averaged 93 and 83 cocks per square mile of managed land for Jasper and Marion counties, respectively. Thus, for nearly two decades, 100 prairie chicken cocks per square mile of sanctuary grassland appeared to be a realistic density goal for Illinois. Two sanctuary systems, each with 1,500 acres, well-situated, properly managed, and well-used by the birds, appeared to be at least minimum goals with which to achieve long-term preservation of the species.

Unfortunately, land acquisition goals were not attained and the favorable responses did not continue into the current decade. By spring 1994 in Jasper County, the count of prairie chickens on booming grounds had declined to six Illinois cocks plus two translocated Minnesota cocks. This brink of extinction occurred despite a new record of nearly 1,000 acres of sanctuary grassland available in 1992 to the prairie chickens at Bogota. The situation was not much better in Marion County where the cock count ranged from 9 to 18 in the past five springs with approximately 500 acres of sanctuary grassland.

Continued on back page

Photo courtesy of T.J. Ulrich

Prairie chicken hen at INHS sanctuary in southern Illinois.

Predicting Juvenile Fish Abundance From Characteristics of the Spring Flood

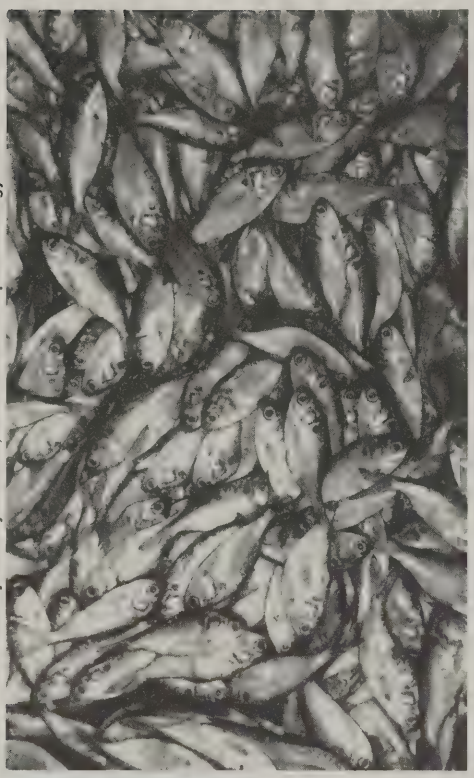


Photo by Timothy B. Smith, INHS Center for Aquatic Ecology

Gizzard shad from Lake Shelbyville.

Fish display enormous reproductive potential and highly variable survival rates during their juvenile year. Individual females of many species annually produce thousands or hundreds of thousands of larvae, most of which die during the first few weeks of life. However, if favorable conditions occur at critical times, larval fish survival may increase substantially, resulting in unusually abundant year classes. Consequently, the number of young fish that eventually reach maturity, or "recruit," may depend to a large extent on the conditions during their early life history.

One idea that biologists have devised to explain the dynamics of early life history and variable fish recruitment is the Match-Mismatch Hypothesis. According to Match-Mismatch, adult animals should spawn when resources are plentiful, thereby enhancing the chance their offspring will recruit. Fish produce more offspring and enjoy greater fitness if they "match" spawning to the peak abundance of the zooplankton diet of their larvae. Individuals that spawn too late or early or during years with low zooplankton abundance "mismatch" and produce slow-growing offspring that either starve or are consumed by predators. Although this idea has been applied primarily to marine ecosystems, freshwater flood pulses also create discrete periods of high productivity similar to those assumed by the Match-Mismatch Hypothesis.

Analyses from Lake Shelbyville, Illinois, a flood-control reservoir built by the Corps of Engineers (COE), have sought to apply the principle of Match-Mismatch to a freshwater system. Each fall, the COE lowers Lake Shelbyville to a level below normal pool. The next year, a significant portion of the spring flood is impounded to inhibit flooding downstream. This flow regulation strategy results in a single, large flood peak within the reservoir that generates a burst of phytoplankton and zooplankton production. Field data from this system show that higher abundance and survival of larval fish occur during the period following floods.

Using seven years of electrofishing data collected in Lake Shelbyville by the INHS Kaskaskia Biological Laboratory, and lake-level data from the COE, we created a simple empirical model based on the principles of the Match-Mismatch Hypothesis to predict juvenile abundance of the omnivorous fish species gizzard shad (*Dorosoma cepedianum*). Assumptions of the model for Lake Shelbyville include 1) adult gizzard shad always produce larvae in excess of carrying capacity, 2) the height of the flood pulse determines the abundance of resources for larval fish, 3) the total number of surviving larval and therefore juvenile fish increases with the availability of flood-generated resources during the larval stage, and 4) larval survival increases as flood pulses near an optimal date that corresponds with a predictable annual peak of sexual maturity within the adult gizzard shad population. Model parameters include the height and the date of the flood peak. For the past two years, this model has produced successful a priori predictions of juvenile gizzard shad abundance, and now explains 83% of the variability in juvenile gizzard shad abundance over the last nine years.

Application of the Match-Mismatch Hypothesis in flood-prone waters may benefit researchers, managers, and resource users. For instance, predictions from the flood model could guide water-level manipulations to manage shad populations to the benefit of sportfish. If Match-Mismatch principles are sufficiently general in freshwaters, knowledge of these interactions may facilitate conservation of economically important or endangered species, particularly in systems with managed flows. Current needs include an exploration of flood-driven recruitment in systems and with species that challenge or violate model assumptions to varying degrees.

Timothy B. Smith and David H. Wahl, Center for Aquatic Ecology

European Corn Borer Management: Past and Present

The European corn borer (ECB), *Ostrinia nubilalis,* is one of the most destructive insect pests of corn in the Midwest. ECB reduces corn yields by 5% annually (a loss of 540 million bushels) at an estimated farm value of $1.1 billion. Populations of ECB in recent years have increased because the trend for less tillage causes less disturbance of overwintering larvae, and early planting of long-season hybrids enhances both generations of ECB. Corn borers may attack any part of the plant above ground from the early whorl stage until corn is harvested. Borers injure plants by feeding on ears and tunneling in stalks and ear shanks. The holes and tunnels weaken the stalks and provide entry for pathogens that cause stalk rot, premature drying, broken plants, ear drop, and subsequent yield loss.

Growers have managed ECB with cultural practices like stalk destruction and fall plowing to reduce overwintering densities. During the growing season, they may apply chemical or microbial insecticides if scouting reveals that ECB densities have exceeded the economic threshold. Although applicators use microbial insecticides, like DiPel, that contain the delta endotoxin of the bacterium *Bacillus thuringiensis (Bt)* to control ECB in the Corn Belt, the effectiveness of these insecticides has been inconsistent. However, the use of *Bt* for control of ECB entered a new era in the spring of 1996 when Ciba Seeds and Mycogen Plant Sciences received approval from the Environmental Protection Agency to sell transgenic corn (*Bt*-corn) with "built-in" insect resistance.

Bt is a bacterium that produces a crystalline protein (delta endotoxin) that is toxic to certain insects. When ingested by a susceptible insect, the protein breaks down in the insect's midgut, causing gut paralysis. The affected insect stops feeding and dies within a couple of days. Modern gene transfer techniques have been used to develop corn plants that contain the endotoxin-producing gene [Cry1A(b)] taken from *Bt.* The endotoxin is expressed at high concentrations in the leaves and other green tissues throughout most or all of the growing season.

For the past three years, scientists at the Illinois Natural History Survey have worked with extension entomologists at the University of Illinois to examine the efficacy of *Bt*-corn against ECB. *Bt*-corn greatly reduces the amount of leaf and stalk feeding by ECB larvae, resulting in more erect plants, fewer dropped ears and broken stalks, and higher yields. One of the benefits of controlling ECB with *Bt*-corn is reduced use of chemical insecticides. *Bt*-corn is not hazardous to the environment and is not toxic to humans and other mammals, birds, fish, and beneficial insects.

The effectiveness of *Bt*-corn varies among hybrids. Because the level of expression of the endotoxin declines in some hybrids after pollination, second-generation borers may survive and tunnel in the stalks, shanks, and ears. Growers must be aware of these differences and adjust their expectations accordingly.

Photo by INHS Center for Economic Entomology staff

Adult European corn borer moth.

A major concern about the use of *Bt*-corn is the potential for ECB to develop resistance to the *Bt* endotoxin. Although field populations of ECB currently are not resistant to *Bt*, a laboratory colony exposed to selection pressure by *Bt* has developed resistance. Therefore, resistance management strategies for the deployment of *Bt*-corn are crucial.

Current studies at the Natural History Survey will help farmers make decisions about using *Bt*-corn. In the near future, transgenic technology likely will produce plants resistant to black cutworms and corn rootworms. These tools will be used in a completely integrated pest management program for long-term benefits to agriculture.

John Shaw and Kevin Steffey, Center for Economic Entomology

Soybean Disease Diagnosis Going High Tech

If you travel through the northern two-thirds of Illinois during late July and August, you may notice soybean leaves turning yellow prematurely. The yellowing of the leaves is due to interveinal necrosis of the leaf tissue. Longitudinally splitting these soybean stems will reveal a dark, reddish-brown discoloration. You are looking at an important soybean disease called brown stem rot. The disease was first reported in Illinois some 50 years ago, and it occurs in the north-central United States and Canada. Brown stem rot, which is caused by the fungus *Phialophora gregata*, is responsible for up to 25% yield loss in soybeans.

Photo by Weidong Chen, INHS Center for Biodiversity

Soybean plot with healthy plants and plants infected with brown stem rot (lighter area at center right).

Brown stem rot is difficult to recognize because it often has no outward symptoms. The most common practice in identifying the disease is by looking at the browning of the soybean stem; however, stem browning is not exclusively associated with brown stem rot. Other fungi also cause browning of the stem but do not cause this disease. Therefore, conclusive identification of the disease involves isolation and identification of the pathogenic fungus from the diseased stem. The process of isolation and identification is time consuming, and a more efficient identification procedure is required for rapid diagnosis of the disease.

We are working to develop an alternative and efficient diagnosis technique of soybean brown stem rot. We collected more than 80 accessions of the pathogen from five north-central states and from Brazil and Japan. Accessions of the pathogen were compared among themselves and with other fungi that are also associated with soybean stems using molecular techniques, such as polymerase chain reaction (PCR) and DNA sequencing. PCR is a technique that allows amplification of a specific piece of DNA from a minute amount of DNA material. We have identified a piece of DNA that is uniquely shared by all the accessions of the pathogen and differentiates the pathogen from other fungi. Based on the sequence information of this unique piece of DNA, we designed oligonucleotides (primers) that allow sensitive detection of the genetic materials of the pathogen within infected soybean plants. By using the PCR technique with the specific DNA primers, we are able to unambiguously identify the brown stem rot disease within hours, whereas the traditional identification process of isolating the pathogen would take three weeks.

The new diagnostic technique is not only fast but also accurate in identifying the brown stem rot disease. In addition, it provides a new tool for scientists to further study the disease in interactions of the pathogen with soybean plants of various cultivars. For example, the technique can be used to study the rate of movement of the pathogen within soybean plants to address fundamental questions concerning the mechanisms of soybean resistance to the disease. We are currently using this technique to study the mechanisms of soybean resistance and to identify new sources of resistance.

Weidong Chen, Center for Biodiversity, in cooperation with Lynn Gray, USDA-Agricultural Research Service at Urbana, and Craig Grau, University of Wisconsin at Madison

Cross sections of stems infected with brown stem rot.

New Publications and Educational Materials

Illinois Mussels

A new color poster showing 30 of the 80 native freshwater mussels of Illinois and 2 exotic bivalves (the Asian clam and zebra mussel) has been published. The poster was produced by the Illinois Department of Natural Resources - Educational Services Section and was developed by Kevin Cummings of the Illinois Natural History Survey's Center for Biodiversity and Robert Warren, archaeologist with the Illinois State Museum (ISM), in cooperation with the Education and Publications Sections of the ISM. Additional funding was provided by the Illinois Department of Transportation, Bureau of Design and Environment.

The poster is two-sided: the front shows the striking diversity of form and color of freshwater mussels (including commercial, common, rare, threatened, endangered, and extinct species); the back contains information on mussel anatomy, life history, commercial harvest, conservation, and a short glossary and bibliography of useful references.

Teachers may obtain single copies free of charge by written request on school letterhead to:

Illinois Department of Natural Resources Educational Services Section
524 South Second Street - Room 530
Springfield, IL 62701-1787.

Individuals, other than teachers, wanting a poster should send $5 (to cover the cost of the mailing tube, postage, and handling) to:

Illinois Natural History Survey
Distribution Center
607 East Peabody Drive
Champaign, IL 61820

Make checks payable to Illinois Natural History Survey.

For more information, please call the INHS Distribution Office at (217) 333-6880.

Field Guide to Northeastern Longhorned Beetles

This hardcover book by Douglas Yanega contains 184 pages including color photos of the nearly 350 species of longhorned beetles to aid in identification. Each photo is accompanied by a complete diagnostic description and synopsis. Chapters also cover beetle morphology, natural history, and collection and care of specimens. The book is designed to be taken into the field. It sells for $15 (price includes postage for domestic or international orders) per copy and can be ordered from:

Illinois Natural History Survey
Distribution Office
607 East Peabody Drive
Champaign, IL 61820
Ph (217) 333-6880

Fishes of Champaign County, Illinois, During a Century of Alterations of a Prairie Ecosystem

The latest in the INHS Bulletin series, Volume 35(2), summarizes four surveys of Champaign County streams from 1889 to 1988. Written by Weldon Larimore and Peter Bayley, this publication compares the abundance, distribution, and variety of fish species collected in the four surveys and how these variables have changed from survey to survey in response to human-induced changes to the ecosystem. *The Fishes of Champaign County* provides accounts of one of the most thoroughly surveyed areas for fishes anywhere on earth. The cost of this bulletin is $10 (price includes postage for domestic or international orders) and it can be obtained at:

Illinois Natural History Survey
Distribution Office
607 East Peabody Drive
Champaign, IL 61820
Ph (217) 333-6880

Land Cover of Illinois

A 1:500,000 scale wall map measuring 52 x 31 inches and containing 20 land-cover classes is available from the Department of Natural Resources. Cost is $5 for folded maps and $10 for unfolded maps shipped in mailing tubes. This striking full-color map shows the location and extent of Illinois' land cover. *Land Cover of Illinois* is based on satellite data and was developed at the Illinois Natural History Survey. For ordering information, please contact:

Illinois Department of Natural Resources - Clearing House
524 S. Second St.
Springfield, IL 62701-1787
Ph (217) 728-7498

Species Spotlight

American Beech

Susan Post

A winter walk in the woods is the best time to appreciate the stately American beech with its rounded crown of many long-spreading and horizontal branches. The most distinguishing feature isn't its shape, however, but the smooth, steel-gray bark that covers the trunk and branches like a tight skin. To the envy of humans, even in old age the beech retains its smooth bark. Unfortunately, this smoothness is as irresistible as wet concrete to human scribes and the bark is usually disfigured by initials or carvings that remain for the life of the tree. This permanent, arboreal record-keeping is made possible by the rapid formation of wound cork (the tree's equivalent to a scab that forms over skinned knees). Tears, cuts, or incisions in the bark are quickly sealed over by the cork cambium, leaving distinctive scars. One of the oldest scars on an American beech was made by Daniel Boone—"D. Boone cilled a bar on tree in year 1760."

Photo by Michael Jeffords, INHS Center for Economic Entomology

American beech, Fagus grandifolia.

Only one species of beech, *Fagus grandifolia*, grows in North America, and colonists quickly learned that its presence indicated good soil; the trees grow in deep, rich loam. Beech trees are typical of the hardwood forests of the eastern United States. In Illinois, growing along the eastern border, they represented a transition between the beech-maple forests to the east and the prairie and oak-hickory forests to the west. The American beech can be found in Lake and Cook counties, the southern fourth of the state, and extending along the eastern border from Vermilion County south.

Beeches are slow-growing and may attain an age of 300 to 400 years. Heights of 70-120 feet are common. Their roots are shallow and spreading, except for a deep tap root. The flowers and leaves appear together, from April to May, and both sexes are on the same tree. Male flowers (staminate) are in round heads on long drooping stems. The female flowers (pistallate) are in clusters on short stems. The leaves are alternate, shiny green, elliptical, and have saw-toothed edges. In the fall they turn yellow or bronze. Pioneers collected the leaves in autumn to fill their mattresses. A settler wrote in 1862, "The smell is grateful and wholesome, they do not harbor vermin, are very elastic and may be replenished annually without cost."

The fruits of the beech are small triangular nuts enclosed in a spiny bur. The bur splits open in October releasing the nut meats. These nuts, which are 20% protein and 50% fat, are responsible for the generic name Fagus, which means "to eat." The early pioneers fattened their Thanksgiving turkeys and hogs on beech nuts. The beech nut was also the number one food choice of the passenger pigeon. A single bird could consume a half pint of nuts a day.

When Prince Maximilian toured the Midwest in 1833, he commented that the beech forests were "the most splendid forests I had yet seen in America." For a glimpse of a beech forest visit the Russell M. Duffen Nature Preserve at Forest Glen in Vermilion County, American Beech Woods Nature Preserve in Lincoln Trail State Park in Clark County, Robeson Hills Nature Preserve in Lawrence County, and along Hamburg Hill in Union County.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

What Tree Is That?

Objective: to acquaint students with the concept of biological keys

Materials: multiple copies of **What Tree Is That?**, leaves from various trees found in the key

Vocabulary: biological key, dichotomous, systematist, taxonomist

Comments: Scientists who locate, describe, name, and determine the relationships of species of organisms to other species are called taxonomists or systematists. To identify organisms, these scientists assemble taxonomic information and arrange it in a logical form called a key. Although there are dozens of types of keys, we will use the dichotomous key, *dich* meaning two parts and *tomous* to divide. Thus, a dichotomous key consists of two choices that have other choices associated with them. Students will construct a key to the leaves of the most common types of trees.

Procedure:

1. Have students learn the various types of leaves and become familiar with the key.

2. Students then try to identify the three unknown samples at the bottom of the activity. Answers: *oak, maple, yellowwood.*

3. Bring in leaves from the various type of trees found in the key and have students attempt to identify each from actual specimens.

The Naturalist's Apprentice

What Tree is That?

Michael Jeffords

What Tree Is That?

Use the key to identify the three unknown trees shown below.

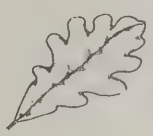
1. Leaves alternate 2
   Leaves opposite or whorled 7
2. Leaves simple 3
   Leaves compound 6
3. Leaves fan-shaped with notch at tip ..... gingko
   Leaves not fan-shaped, lacking notch at tip 4
4. Leaves entire ..... magnolias
   Leaves lobed or toothed 5
5. Leaves lobed ..... oaks
   Leaves toothed ..... elms
6. Leaflets small ..... honeylocust
   Leaflets large ..... yellowwood
7. Leaves whorled ..... catalpa
   Leaves opposite 8
8. Leaves simple 9
   Leaves compound 10
9. Leaves palmately lobed ..... maples
   Leaves entire ..... dogwoods
10. Leaves palmately compound ..... buckeyes
    Leaves pinnately compound ..... ashes

Leaf Types Used in Key

fan-shaped

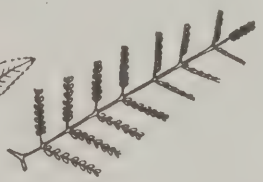
entire

lobed



toothed

small leaflet



large leaflet

whorled

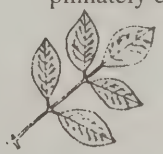
opposite

compound

palmately lobed

palmately compound

pinnately compound



simple

Unknowns:

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Prairie Chickens

continued from front page

Factors documented to have decimated prairie chicken numbers include (1) poor nest success due to predation in some years, (2) intense interactions with pheasants, (3) declining egg quality symptomatic of genetic deficiencies, and (4) intensifying land use on private cropland adjacent to the sanctuaries (the list of other probable negative factors is too long for this report). Illinois Department of Natural Resources (IDNR) sanctuary managers have successfully controlled nest predators and pheasants in recent years. So far, genetic management via translocation of prairie chickens from large populations in Minnesota, Kansas, and Nebraska also appears successful. From only 6 Illinois cocks in spring 1994, numbers increased to 70 cocks by spring 1996 on at least four well-established booming grounds in Jasper County. Limited data on egg fertility and hatchability suggest that egg quality has returned to normal. Moreover, new sanctuary acquisitions by the IDNR of 60 and 215 acres in 1995 bring the total to 1,636 acres in Jasper County. These changes enhance the survival prospects for prairie chickens in Illinois.

Still, an answer to our initial question, How much grassland is enough?, remains evasive. Attainment of 1,500 acres of quality grassland may soon become a reality, at least in Jasper County.

Photo courtesy of T.J. Ulrich

Prairie chicken boomer.

Sanctuary land in Marion County remains at 760 acres, only half the minimum goal.

Estimates derived from one predictive model suggest a need for about 4,000 acres of suitable grassland to sustain a population containing 200-250 prairie chicken cocks. The estimate from this model was based on prairie chicken research in Minnesota and Wisconsin conducted on range acquired after European settlement, that is, not the species' original range. Application of the same formula to Illinois data (using means for interbooming ground distances and cock numbers per booming ground) suggests that only 1,500 acres may indeed do wonders on Illinois' original prairie chicken range. This quantity of grassland appears especially workable if brome (*Bromus inermis*), a preferred grass, is emphasized in sanctuary management. However, using several other estimation approaches, a need for several thousand acres of grassland is indicated. Currently, some geneticists calculate that more than 10,000 individuals might be needed to ensure long-term species survival. Researchers are clearly challenged to identify quality habitats and determine how much will be enough.

Ron Westemeier, Center for Wildlife Ecology

Illinois Natural History Survey Reports is published bimonthly by the Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820. Headquartered on the campus of the University of Illinois at Urbana-Champaign, the Survey is a division of the Illinois Department of Natural Resources

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ILLINOIS NATURAL HISTORY SURVEY

Reports

March/
April 1997
No. 344

INSIDE

Raccoon Health Watch

Late at night you may hear rustling in your garbage or see a fat, sleek animal bandit dash across the street. Raccoons are becoming more and more common in suburbs and towns as well as in rural areas. The increase in Illinois wildlife enhances our environs, but human-wildlife interactions can also have some negative consequences.

The Illinois Natural History Survey Center for Wildlife Ecology and the University of Illinois College of Veterinary Medicine have been collaborating on a study to evaluate the health of wild raccoons. Raccoons were given physical examinations and blood and fecal samples were collected to test for diseases that can be harmful to humans, pets, or livestock.

One of the most common infections found in raccoons was leptospirosis. Almost 50% of the healthy raccoons showed current or previous infections with Leptospira bacteria. This organism can also spread to humans and their pets causing ailments ranging from mild, flu-like symptoms to severe disease. Leptospirosis is transmitted when the bacteria, which are usually excreted in urine, come in contact with mucous membranes or broken skin. The organisms can survive for long periods of time in warm, stagnant water. People handling raccoons should wear gloves and those engaging in recreational activities in areas of high raccoon density should be made aware of the risks. In Hawaii, signs are posted along many streams and wetlands warning of the hazards of leptospirosis; however, the risk there is higher because of the warmer climate.

Photo by Michael Jeffords, INHS Center for Economic Entomology

Raccoon in an urban tree.

Infection with canine distemper virus ranged from 20% to 30% across the three years of the study. Deaths due to distemper occurred every year and an outbreak, with considerable mortality, occurred in one area. The virus also seemed to cause a generalized suppression of the raccoons' immune systems, resulting in susceptibility to other parasites and diseases. Distemper is not a zoonosis, so humans cannot get the disease. However, distemper from raccoons does pose a hazard for pet dogs that are not properly vaccinated. Distemper is also a major source of mortality for raccoons, especially in areas of high density. Recent

Continued on back page

Botany of the Savanna Army Depot

In 1917, at the height of World War I, the United States Army was searching for remote, sparsely populated sites to test and store munitions. A huge expanse of sand near the Mississippi River in northwestern Illinois (Carroll and Jo Daviess counties) fit the bill and the Savanna Army Depot was established. Now, 80 years later, the depot is being decommissioned. The Illinois Department of Natural Resources (DNR), together with various federal agencies, is gathering data to help plan the depot's future. Our team of botanists from the Illinois Natural History Survey's (INHS) Center for Biodiversity is responsible for surveying the plants.

Photo by Ken Robertson, INHS Center for Biodiversity

INHS Center for Biodiversity researchers (l-r) Mike Moore, Geoff Levin, Rick Phillippe, and Kate Kramer at Savanna Army Depot.

The Army probably did not recognize the tremendous biological significance of the depot when it was established, but its extensive sands are very unusual in Illinois. Previous DNR-sponsored surveys of the depot had located 11 threatened or endangered plant species. With increased access to the base, we discovered one additional state endangered species and many previously unknown populations of the others. We also found at least one plant previously unknown from Illinois that should be a candidate for threatened or endangered status.

Many of the depot's rare plants are western species that reach their eastern limits on sandy habitats in western Illinois. Two of these, hairy umbrella wort (*Mirabilis hirsuta*) and fragile prickly pear (*Opuntia fragilis*), are known in Illinois only in Jo Daviess County, and the latter is known only from the Savanna Army Depot. Others, like James's clammyweed (*Polanisia jamesii*) and shaved sedge (*Carex tonsa*) have their largest Illinois populations on the depot. Some of the depot's animals show a similar pattern. For example, the only population of white-tailed jackrabbits (*Lepus townsendii*) east of the Mississippi River was at the depot. Unfortunately, the jackrabbits disappeared in recent years, probably due to habitat changes and increased numbers of coyotes.

Perhaps even more significant than the individual plant species are the depot's natural communities. Most noteworthy are its extensive prairies and savannas. The savanna habitat, which consists of trees, typically oaks, scattered through a grassland, has almost disappeared from North America. Only about 6,400 acres of tallgrass savanna remain in the United States, about 0.02% of the presettlement total. Prairies have seen similar losses. The depot, with about 3,500 acres of savanna and prairie, preserves the most extensive remaining stands of these communities in the state.

The natural communities of the depot are not pristine, however. For obvious reasons, the Army has vigorously suppressed fires, which are vital for preserving both prairie and savanna from encroaching forests. Cattle have been used to reduce grassy vegetation and thereby reduce fire intensity. Though the cattle probably have slowed forest encroachment, they have also modified the grassland and forest vegetation. We have been uniquely able to document changes in the depot's vegetation because not long before the Army acquired the land, noted ecologist Henry Allan Gleason, then at INHS, published a paper describing the vegetation of the major sand deposits in Illinois, including the region that became the depot. Overall, we observed that forest cover of the depot has increased, particularly in areas that formerly were savanna. In addition, the abundance of some shrubs and grasses has increased, whereas other grasses and forbs that are probably dependent on periodic fires have decreased in abundance.

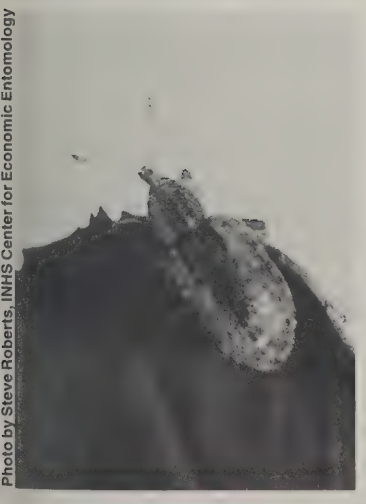
Still, much of the Savanna Army Depot remains in vegetation that with proper management could significantly recover. Nowhere else in Illinois can one look across a landscape so extensively covered with prairie and savanna. As decisions are being made for the depot's future, our research provides the information needed to find ways to use the land that help preserve this remarkable remnant of our state's natural heritage.

Geoffrey A. Levin, Kenneth R. Robertson, Kathryn A. Kramer, and Loy R. Phillippe, Center for Biodiversity

Forage Crops (Integrated Pest Management)

The alfalfa weevil and potato leafhopper are serious alfalfa pests in Illinois as well as other states. Weevil larvae hatch from eggs laid in alfalfa stems and begin to develop in the leaf folds of the growing tips. As they mature and begin to eat more, weevils move to the other leaves and begin to remove much of the leaf surface. Weevils are especially destructive to the first-crop alfalfa. Potato leafhoppers, on the other hand, are normally more damaging to the second and third crops of alfalfa. Leafhoppers feed by piercing and sucking the juices from the plant tissue. This causes plant stunting, yellowing, and leaf drop, greatly reducing the quality of the alfalfa.

To successfully control both of these pests, growers must pay particular attention to the proper timing of control practices whether they be insecticidal or alternative measures. In addition, a successful pest management program must take into consideration the influence of predators, parasites, and pathogens of each pest. Other factors, such as plant height and stage of growth, are important considerations.



Alfalfa weevil adult.

Management practices that result in a reduced pesticide load to the environment are especially important in alfalfa production. Alfalfa hay must be free of pesticide contamination in order to produce acceptable dairy products. Illinois Natural History Survey entomologists and University of Illinois Extension personnel are cooperating with their counterparts at the University of Missouri to investigate various alternative control practices and management systems for alfalfa weevil control that are not totally dependent on pesticides. In doing so, researchers are determining which life stage of the insect is most vulnerable, and this may not often be the same stage that causes the damage. Because the weevil deposits its eggs in the plant stem during the fall, winter, and early spring, an attack at this stage may reduce the damaging larval population to below the economic threshold.

Investigations are under way to determine the impact of early spring livestock grazing to reduce overwintering egg populations. This nonpesticide practice for weevil control may be successful; however, other factors, such as yield, plant vigor, and stand longevity, must be considered. Scientists are also studying other means of reducing the egg population, such as a late fall harvest after the first frost and winter burning of the alfalfa stems.

However, these and other practices may have detrimental influences on the predators, parasites, and pathogens that also provide alfalfa weevil control by reducing larval and adult weevil populations. A number of types of tiny wasps attack the life stages and have proven to be successful in helping to reduce population numbers. A fungal pathogen is especially destructive to larvae in certain years when climatic conditions are ideal for development of the pathogen. An ideal management system must consider all the various control tools including the interactions of one with the others. Entomological research of this type coupled with expertise in crop production and extension activities can result in successful alfalfa production and insect control.

Alfalfa weevil larvae feeding on plant.

Edward J. Armbrust and Stephen J. Roberts, Center for Economic Entomology

River Levels and Largemouth Bass Populations in the Illinois River

Although the population dynamics of largemouth bass (*Micropterus salmoides*) in ponds, lakes, and reservoirs have been studied extensively, relatively little is known about those population dynamics in temperate large river-floodplain ecosystems. River levels likely affect fish populations in these systems during certain times of the year (e.g., spawning) because they can determine habitat availability and quality. Because river level regimes vary annually, long-term data sets are needed to understand fish population dynamics in these systems over a wide array of environmental conditions.

Photo by Paul Raibley, INHS Center for Aquatic Ecology

Largemouth bass taken in the Illinois River.

While floods are generally perceived to have negative impacts on humans, studies indicate fish populations in large river-floodplain systems benefit from seasonal flood pulses. The magnitude of the effect of these flood pulses is determined by water temperature, rates of water rise and fall, and the extent and duration of floodplain inundation. Because most Illinois River backwater lakes presently lack vegetation and have soft, silty substrates, they are less than ideal habitats for spawning fish. Spawning fish may utilize annual spring floods to access inundated terrestrial vegetation and previously dry, compact substrates on the Illinois River floodplain.

We examined the relationship of river level and temperature to largemouth bass population structure in La Grange Reach (a 125.6-km segment between La Grange Lock and Dam and Peoria Lock and Dam) of the Illinois River from 1990 to 1995. Fish were collected with a pulsed-DC electrofishing boat along randomly selected segments of backwater, side channel, and main channel shoreline as part of the Long Term Resource Monitoring Program (LTRMP). We used the percent of the fish less than 120 mm (5 inches) long from each year's sample as an index of year class strength for young-of-the-year (age-0) fish. Of 218 bass we have aged since 1993 that were less than 120 mm long, 96.8% were age 0.

We made 591 electrofishing collections (150.6 hours) from 1990 through 1995 and collected a total of 2,563 bass. In three of the six years (1990, 1993, and 1995) age-0 fish made up more than 20% of the total catch, indicating strong year classes were produced. These year classes remained strong in subsequent years as evidenced by their presence in our annual collections. Floodwaters coincided with warming water temperatures and bass spawning times in each of these years. In 1993 water covered the floodplain for nearly nine months (March through October), greatly expanding spawning and nursery habitat which resulted in high fish production and low mortality; age-0 bass made up 58.3% of our catch that year. Although river levels fell during spawning in 1993, the floodplain remained inundated throughout most of that time and river levels remained low for only a few days before rising again, reinundating the floodplain. As a result, bass mortality due to nest abandonment and stranding may have been low.

In 1991, 1992, and 1994, age-0 fish made up less than 7% of our catch, indicating weak year classes were produced. In 1991 river levels fell rapidly during

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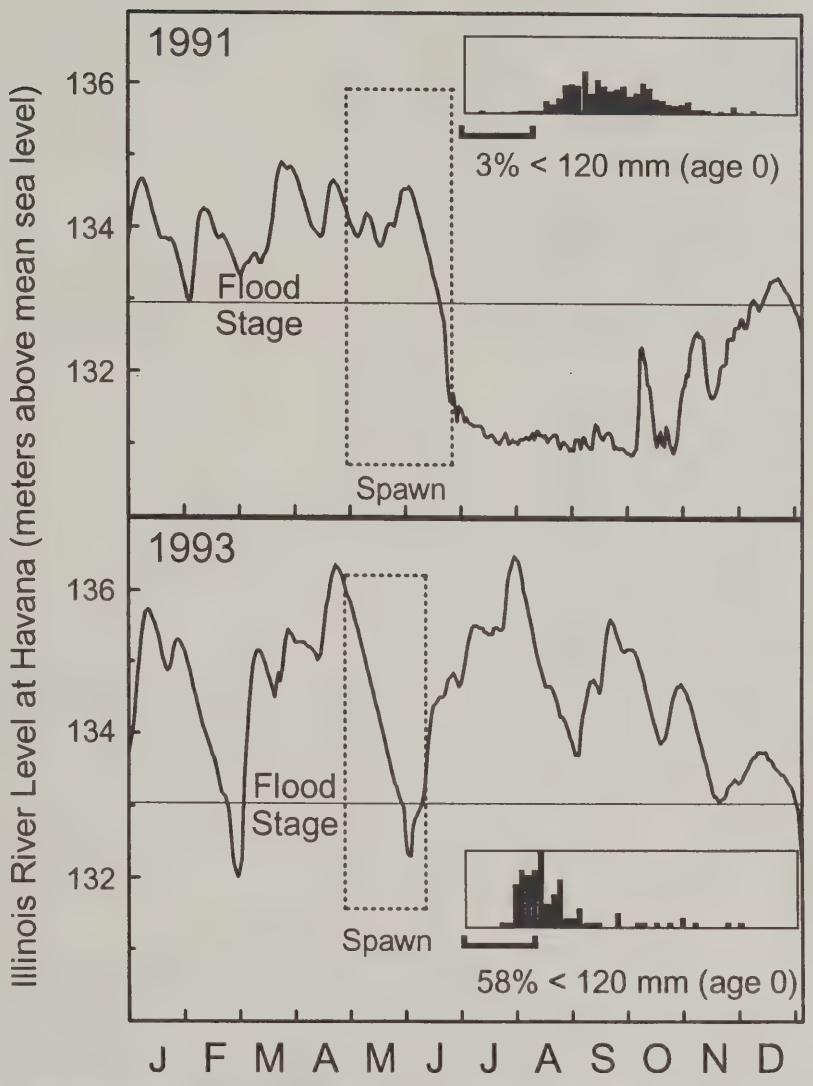
Bass

continued from previous page

June, draining the floodplain and probably causing fish to abandon nests. Because river levels fell rapidly, many age-0 fish may have been flushed off the floodplain or become stranded, resulting in high mortality. In 1992 and 1994 river levels were low and fluctuating as temperatures warmed and bass were spawning. Under these conditions, suitable spawning habitat may have been limited and survival rates of age-0 fish may have been low due to predation.

The coincidence of flood events with the production of strong largemouth bass year classes in La Grange Reach (1990, 1993, 1995) indicates floods are often beneficial to Illinois River fish populations. Other nest-building fish species in La Grange Reach (bluegill, *Lepomis macrochirus*; black crappie, *Pomoxis nigromaculatus*; and white crappie, *Pomoxis annularis*) exhibited population dynamics similar to largemouth bass and seemed to benefit from high spring and early-summer river levels. We also documented strong cohorts of age-0 gizzard shad, *Dorosoma cepedianum* (a major food source for Illinois River fish), when river levels were high during spring, which may have enhanced bass survival.

Over the past six years we have gained insight into the relationship between spring river levels and fish production in La Grange Reach, but our knowledge is still lacking in many areas. For example, what are the effects of droughts on fish populations in La Grange Reach? As we continue to monitor Illinois River fish populations and other LTRMP biologists continue to monitor Mississippi River fish populations, our understanding of fish population dynamics in temperate, large river-floodplain ecosystems will improve.



River levels at Havana, IL, in 1991 and 1993. In 1991 river levels fell below flood stage in June and remained low all summer. In 1993 river levels fell slightly below flood stage in May, but rose again within a few days, covering the floodplain throughout summer. Age-0 largemouth bass (< 120 mm long) accounted for 3% of all bass collected in 1991 and 58% in 1993.

Paul T. Raibley and Richard E. Sparks, Center for Aquatic Ecology

Species Spotlight

Yellow-headed Blackbird

Susan Post

The yellow-headed blackbird is a robin-sized bird, larger than its cousin the red-winged blackbird. Its Latin name, *Xanthocephalus xanthocephalus*, literally means yellow head and refers to the male whose head, neck, and upper breast are bright yellow. Its body is black with white wing patches. The female is dark brown with a yellow patch on her chest. Yellow-headed blackbirds are found in marshes with adjacent open lands, and once the cattails and bulrushes grow tall, the bird is often heard before seen. Its call is unlike its cousin's melodic "skree," but instead has been described as a "rusty hinge," "a guttural croak," or more poetically as "the wail of despairing agony which would do credit to a dying catamount."

Photo by Richard Graber, INHS

Yellowheaded blackbird, Xanthocephalus xanthocephalus.

The yellow-headed blackbird is basically a western species. Its breeding range extends from central Washington to southern California and as far east as Illinois. It once was a fairly common nester in the marshy regions of Chicago, but now is only occasionally found in Lake, Cook, McHenry, Rock Island, and Cass counties.

Yellow-headed blackbirds arrive on their breeding grounds from late March to early May. The birds nest in colonies with each male vigorously defending its "turf." Territories are established in permanent marshes and sloughs that have water 2-4 feet deep and thick vegetation. The deep water deters skunks and raccoons while the thick vegetation and a communal defense are good protection against hawks and crows. If the water levels drop too far during the nesting period, the birds will abandon the nest. The female builds a nest by weaving soggy blades of dead grass that she attaches to cattail stems. When the woven grasses dry, they are drawn together to form a tight structure. The nest takes 2-4 days to construct and the finished product is a basket 5-6 inches in diameter and 2-3 inches above the water.

The female now begins to lay eggs—one whitish egg with brown flecks per day. She usually lays 3-5 eggs and is in charge of incubating them. Once they hatch, the young are fed aquatic insects that contain the protein necessary for swift growth. After 9-12 days the young leave the nest and by three weeks they are making short flights.

Perhaps the best place to view these yellow-headed blackbirds is Willow Flats Pull Off in Grand Teton National Park. Here bold males and juveniles will pick the insects out of your radiator while you watch! If a trip out West isn't in your future, Moraine Hills State Park in McHenry County offers a good viewing opportunity. Take advantage of the Fox River hiking trail which leads to an observation platform over Black Tern Marsh. Scan the marsh for a glimpse of a yellow-headed blackbird. If you forget your binoculars, don't despair; for its call, of which raucous is too polite a descriptor, will surely give it away.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

What's in a Wetland?

Objective: to learn some of the diverse groups of creatures that inhabit Illinois wetlands

Materials: multiple copies of **What's in a Wetland?**

Vocabulary: community, food web, inventory

Comments: The plants and animals found in wetlands are extremely diverse and form communities that can be very complex. The organisms are tied to one another by food webs, nutrient cycles, and other ecological interactions. One of the first steps a biologist takes in trying to understand the ecological relationships in a given habitat is to do an inventory and identify the different types of plants and animals that live there. Students will use the accompanying poster to conduct a simple inventory of this Illinois wetland.

Procedure:

1. Give each student a copy of the drawing and have him or her place the organisms into the following categories: plants *(12)*, birds *(9)*, mammals *(2)*, insects *(2)*, fish *(2)*, mollusk *(1)*, and reptile and amphibian *(3)*. Use the numbers following the groups to check correct answers.

The Naturalist's Apprentice

What's in a Wetland?

Michael Jeffords

What's in a Wetland?
Count the number of different kinds of organisms found in this wetland and record your answers here:

___plants ___birds ___mammals ___insects ___fish ___mollusks ___reptiles & amphibians

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Raccoons

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studies suggest that this raccoon/canine virus may cause severe disease in exotic cats, such as lions and panthers. Raccoons should not be transported from one area to another because they may start epidemics among other raccoons or dogs. All dogs that have contact with wildlife should be regularly vaccinated for distemper.

Almost half of the raccoons had antibodies to toxoplasma and the infection rate increased with age. Although cats (both domestic and wild) are the only species that can shed toxoplasma eggs, many other species, including humans and raccoons, can become infected. In humans, infection is inconsequential unless it occurs for the first time in a woman, while she is pregnant. If the organism is passed to the fetus, severe birth defects can result. Toxoplasmosis can also be life threatening for AIDS patients and patients on chemotherapy for cancer or organ transplants. Illinois raccoons thus serve as a sentinel of toxoplasma in the environment as well as a source of infection for humans who consume raccoon meat. Pregnant women and people experiencing immunosuppression should be careful to avoid contact with soil when in natural areas. The microscopic toxoplasma eggs must be ingested to be infective; however, eating without washing hands could allow infection.

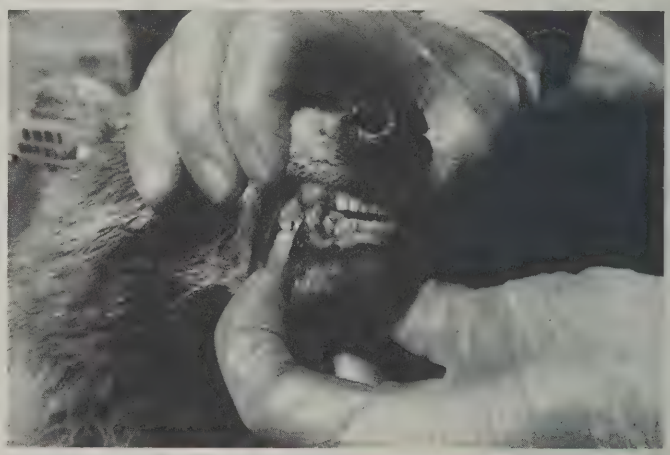

Photo by Laura Hungerford, INHS Center for Wildlife Ecology

Raccoon with dental problems caused by ingesting human food.

Several of the agents identified in fecal samples (*Baylisascaris procyonis*, *Capillaria* sp., and hookworms) pose health hazards for humans and domestic species, especially birds, dogs, and exotic animals. Contaminated soil serves as the main source of exposure. Raccoon feces should not be allowed to accumulate in areas used recreationally by humans or around homes. Facilities for hand washing should be readily accessible in picnic areas. Although humans are not likely to be exposed by close contact with raccoons, raccoons often defecate near where they feed; therefore, feeding raccoons should be discouraged.

Raccoons also showed some negative effects following association with humans. Raccoons that lived in a state park and were fed by visitors had higher rates of dental caries and gum disease as well as higher cholesterol levels than those living in a farming area.

Further studies are continuing to examine the health of raccoons in urban areas and to evaluate how diseases affect animal behavior and movements. By better understanding the potential for disease occurrence at the interface between humans and wildlife, we can take measures for humans to enjoy wild species while minimizing health hazards to humans, pets, and wildlife.

Laura Hungerford, Center for Wildlife Ecology

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ILLINOIS NATURAL HISTORY SURVEY

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INSIDE

Effects of Sedimentation on Stream Communities

Excessive input of fine sediment (sand, silt, clay) generally is considered to be the most prevalent form of pollution currently affecting streams and rivers in the United States. Because of the erosive force of flowing water, the presence of fine sediment in streams is an entirely natural phenomenon. In fact, a dynamic balance in streams normally exists between the particle size and amount of sediment transported by a stream, and the discharge and slope of the stream. A variety of human activities can lead to abnormally high rates of sediment input, upsetting this balance and resulting in increased concentrations of sediment in the water column (i.e., increased turbidity) and increased deposition of sediment on the stream bottom. Both of these factors can have serious adverse effects on the biota and ecology of streams.

McPherson Creek, a highly impacted stream at Fort Bragg, showing large amounts of suspended sandy sediment filling the shallow stream channel.

The major anthropogenic sources of sediment to streams are agriculture (especially row-crop cultivation in floodplains and livestock grazing in riparian zones), forestry (with logging roads contributing far more sediment than other practices, including clear-cutting), mining, and urban development. Of these, agriculture is by far the most significant source of anthropogenically derived sediment. It has been estimated that agriculture contributes about 50% of all sediment pollution in the United States.

Several factors make it difficult to study the effects of increased sedimentation on stream communities in natural settings. First, inputs of sediment to streams are often diffuse rather than localized. This makes identification of potentially impacted and relatively unimpacted reaches of stream problematic. In addition, inputs of sediment often may be associated with other sources of pollution (e.g., plant growth nutrients, such as nitrogen and phosphorus, and pesticides). This is especially likely to be true in watersheds where agriculture and urbanization are dominant forms of land use. In such situations, it may be difficult to separate effects of sedimentation from other factors.

Photo by Dan Soluk, INHS Center for Aquatic Ecology

Pristine site upstream from impacted areas. Note clear deeper water and abundant woody debris.

Survey scientists recently had the opportunity to conduct research in a setting where such potentially confounding factors should have been relatively unimportant. Numerous streams flow through a U.S. Army installation, Fort Bragg, located in the sandhills region of North Carolina near Fayetteville. In contrast to most streams where effects of sedimentation had been studied, streams at Fort Bragg are naturally soft-bottomed (i.e., largely sand and silt bottom sediments) and slow-flowing. Because of the noncalcareous, predominantly sandy soils that the streams drain, streams in this region have low concentration of dissolved salts, low pH, and are relatively unproductive. Despite their low productivity, these streams support very diverse fish and invertebrate faunas.

A variety of land use practices at the installation were thought to affect rates of sediment input to some streams or stream segments on the base. The most significant sources of sediment were expected to be 1) the construction and intensive use of unpaved, sandy roads, especially where such roads intersected streams, and 2) the virtual devegetation of large tracts of land for paratroop drop zones. Both of these sources result in relatively localized inputs of sediment that, because agriculture is not practiced in watersheds on the base, should not be associated with other potential pollutants (e.g., nutrients, pesticides).

Continued on back page

Illinois Springs

Springs are a natural source of groundwater discharge at a rate high enough to form a channel on the earth's surface. The physical and chemical composition of spring water reflects not only the mineral composition of the various rock strata with which the water has been in contact but also the various chemicals that percolate into groundwater. Even though springs provide a unique interface between groundwater and surface water, they have only recently become a focal point of research in Illinois.

Along with their associated seeps and outflow brooks, springs provide a unique habitat for endemic (restricted to a localized area) and relict species of animals and plants because they usually provide a nearly constant physical and chemical environment. Until recently, little emphasis had been given to the study of springs in Illinois, particularly from the perspective of species richness and endemism in relation to water quality. Past studies of springs generally focused on a selected taxonomic group, but provided minimal water quality information other than water temperature, dissolved oxygen, hydrogen ion concentration (as pH), and alkalinity. Aquatic macroinvertebrates of temperate, cold-water areas are dominated by either a noninsectan community (Turbellaria, Annelida, Amphipoda, Isopoda, Gastropoda) or an aquatic insect community (Odonata, Ephemeroptera, Plecoptera, aquatic Diptera, Trichoptera, and aquatic Coleoptera). Faunal dominance by noninsectan species appears in hardwater limestone springs with a pH greater than 7.0 and an alkalinity above 25 mg/L (as $CaCO_3$). Aquatic insects appear to dominate the fauna in both acidic and soft-water springs—those with a pH less than 7.0 and an alkalinity below 25 mg/L.

Photo by Mark Wetzel, INHS Center for Biodiversity

Don Webb of INHS searches for aquatic invertebrates.

With the passage of the Clean Water Act of 1972, which called for state funding for groundwater management and water quality programs, states were required to develop biological criteria for the protection of aquatic communities. As recently as 1990, baseline information on the fauna, flora, water quality, and hydrogeology was virtually nonexistent for springs in Illinois. A cooperative program between the Illinois Natural History Survey and the Illinois State Geological Survey was initiated in 1991 to evaluate the current status of Illinois springs, in particular the biota and their relation to groundwater quality. Many locations of springs were determined from topographic maps; additional locations were provided by residents throughout the state. All information on Illinois springs is entered into a computerized database. Early in this century, 88 springs were documented for Illinois. To date, information on 300 springs is included in this database.

The majority of Illinois springs are located in the Mississippian, Devonian, and Pennsylvanian limestone and sandstone of the Shawnee Hills and the western border of Illinois. Several springs also originate from the base of the bluffs along the Fox, Illinois, and Rock rivers. Only a few springs, however, are listed from the central plains of Illinois.

Our first intensive survey of Illinois springs focused on seven springs in the Shawnee Hills of southern Illinois. This karst (limestone) region lies outside the areas of intensive agriculture where groundwater contamination from the annual application of agricultural fertilizers and herbicides was expected to be minimal. Thus, the conditions in these springs could be utilized as a benchmark for comparison with other springs in Illinois. Each of these springs was small in size, with a low discharge rate and a substrate consisting generally of sand and small gravel. High concentrations of total dissolved solids and chlorides were measured at Saline Spring and Salt Well Spring, both located in an area of high salinity southeast of Equality in Gallatin County. Springs in this area historically were used as salt wells by native Americans and early settlers. Nitrate nitrogen concentrations were below background levels (1.4 mg/L) and herbicide concentrations were below detection levels.

Eighty-five species of aquatic macroinvertebrates were collected from these seven springs with an average of 27 species per spring. Noninsectan macroinvertebrates dominated this fauna and were species common to most small surface streams in the Shawnee Hills. Oligochaete worms (24 species) represented the most diverse faunal group with *Varichaetadrilus angustipenis* (Tubificidae)—rarely collected in Illinois and within a limited distribution in North America—recorded from six of the springs. *Allonais paraguayensis* (Naididae) from Old Driver and Salt Well springs, previously known only from Louisiana, South Carolina, and an aquarium in New York, was the most interesting of the species collected. Few aquatic insects were collected and, when present, were low in abundance. The water quality of these springs in the Shawnee Hills is high and the

Continued on next page

Illinois Springs

continued from previous page

diversity of the aquatic macroinvertebrates is considered low but stable.

A second study focused on 10 karst springs in Monroe and St. Clair counties. This area, often termed "The Sinkhole Plain," is a limestone area with a thin layer of topsoil. Water percolating through the cracks and fissures has dissolved away the limestone, forming an extensive network of underground caves and streams in a pattern resembling a large piece of Swiss cheese and covering two counties. Surface runoff in this area has the opportunity to move quickly through these underground conduits in a matter of hours, rather than taking years to seep slowly through the soil. Geochronologically, these 10 karst springs were assigned to three limestone formations of the Valmeyeran Series of the Mississippian Age. Results from age-dated springs in Monroe and St. Clair counties indicated that these springs were actively discharging water approximately 11,000 years ago.

It was here that a "worst-case scenario" with regard to the biodiversity and water quality was expected. Contamination of these 10 springs from nitrate nitrogen and herbicides was expected to be high, and at levels that would adversely affect the diversity of aquatic macroinvertebrates. In addition, aquatic macroinvertebrate species common to surface streams in or adjacent to the study area, and broadly tolerant of environmental perturbations, were expected to occur in these springs.

We collected 141 species of aquatic macroinvertebrates with an average of 42 species per spring. Again, aquatic oligochaetes, amphipods, isopods, and turbellarians were the most abundant macroinvertebrates. Although aquatic insects represented the most diverse group (80 species), their abundance was generally low. Only the mayfly genera *Baetis* and *Stenonema* and the caddisfly *Cheumatopsyche analis* were moderately abundant. Oligochaetes again were the most diverse group of noninsectan organisms (33 species), with both *Varichaetadrilus angustipenis* and *Allonais paraguayensis* present in these springs. Another oligochaete, *Bratislavia unidentata* (Naididae), considered rare in Illinois and uncommon throughout its North American distribution, was collected from Sparrow Spring and its springbrook.

Nitrate nitrogen in groundwater is an anion that can be derived from several naturally occurring sources. As an anion, it is not readily adsorbed to soil components, thus it readily migrates through the soil into the groundwater system. Researchers of the Illinois State Geological Survey were able to determine a background threshold of 1.4 mg/L for nitrate nitrogen in the karst terrain area of southwestern Illinois based on a previously developed probability technique. Concentrations below 1.4 mg/L were considered natural in their derivation; those above 1.4 mg/L were considered to be of man-made origin. Nitrate nitrogen was present in all 40 water samples collected from the springs, with 39 of the samples reporting levels above the background concentration; however, none exceeded the USEPA Maximum Contaminant Level (USEPA MCL) of 10 mg/L.

At least one of four herbicides (Atrazine, Alachlor, Cyanazine, and Metolachlor) was detected in 33 of the 40 water samples. Atrazine was detected in 73% of the samples; three of these exceeded the USEPA MCL of 3 µg/L. Alachlor was detected in 27.5% of the samples; one exceeded the USEPA MCL of 2 µg/L. Cyanazine was detected in 22.5% of the samples; two of these exceeded the USEPA Health Advisory Limit (USEPA HAL) of 1 µg/L. Metolachlor was detected in 47.5% of the samples. No samples exceeded the USEPA HAL of 100 µg/L.

In general, a "worst-case scenario" regarding the diversity of aquatic macroinvertebrates was not observed in these 10 karst springs. The cave-inhabiting amphipods *Crangonyx forbesi* and *Gammarus troglophilus*, and the cave-inhabiting isopod *Caecidotea packardi*, were collected from seven, eight, and three karst springs, respectively. A positive linear correlation between drainage basin area and aquatic macroinvertebrate species richness was determined for 9 of the 10 springs studied. In comparison, the seven Shawnee Hills springs supported an average of 27 species per spring. Only two amphipod species, *Gammarus minus* and *Gammarus pseudolimnaeus*, were collected from springs in the Shawnee Hills; these species are relatively common to surface streams of southern Illinois.

Photo by Phil C. Reed, Illinois State Geological Survey

Mark Wetzel of INHS, sampling spring.

No aquatic macrophytes, little filamentous algae, and no animals or plants listed as endangered or threatened were observed or collected in any of the springs examined in the Shawnee Hills or the Sinkhole Plain.

Research on the springs of Illinois is continuing; numerous springs in the Lincoln Hills Section of western Illinois were sampled during 1996. Springs in the Driftless Area of Northwestern Illinois and the few scattered springs located throughout the Grand Prairie Division of north-central Illinois will be sampled during 1997. This study will allow us to complete an assessment of the community diversity of aquatic macroinvertebrates associated with springs in Illinois, and the relationship of the overall groundwater chemistry with those populations.

D.W. Webb, M.J. Wetzel, and L.R. Phillippe, Illinois Natural History Survey; P.C. Reed and T.C. Young, Illinois State Geological Survey

What Color Are Your Squirrels?

Since 1820, about 69% of the original woodland habitat of Illinois has been removed. Most of the remaining large wooded areas are in the southern part of the state. East-central Illinois historically had less forest cover, with prairie making up most of the landscape, but what woodland habitat there was has been drastically reduced. Woodland habitat is also highly fragmented. For example, the woodlands that remain in east-central Illinois are widely scattered and exist mainly in the form of isolated farmstead woodlots or as narrow strips along rivers and streams.

Forest-dependent species of mammals can be affected by this reduction and fragmentation of habitat. Species that are mobile and readily traverse a variety of habitat types, such as deer, raccoons, or white-footed mice, still are ubiquitous among patches of forest in these landscapes. However, species with poor dispersal abilities or that are averse to leaving forest cover, such as flying squirrels, chipmunks, and woodland voles, may disappear from all but the largest tracts of forest when habitat patches become small and isolated.

Photo by Ed Heske, INHS Center for Wildlife Ecology

Dan Rosenblatt with a fox squirrel and a gray squirrel ready to be radio-collarded and relocated.

Gray squirrels (*Sciurus carolinensis*) and fox squirrels (*Sciurus niger*) seem to respond differently to forest fragmentation. Historically, gray squirrels were widespread throughout Illinois and outnumbered fox squirrels in forested areas. As forested areas were cut, thinned, or grazed, fox squirrels increased in abundance and gray squirrels often declined. Now, gray squirrels are absent from many parts of their former range, although they have adapted well to many urban areas. Gray squirrels can be very abundant in some urban areas, as anyone with a bird feeder or a garden planted with tulip bulbs can attest, but they have been replaced by fox squirrels in many rural areas.

In east-central Illinois, gray squirrels are currently found only within some urban areas and continuous riverine forests, and are absent from isolated non-urban areas. In contrast, fox squirrels are numerically dominant to gray squirrels throughout the countryside. Although gray squirrels have been successfully reintroduced to some urban areas and a few large, forested areas, they have not spread out from these sites to fill their former range. What biological mechanisms might account for the different distributions of these two similar species?

Habitat fragmentation can lead to changes in the physical environment in remnant patches. In spite of the behavior of gray squirrels in urban areas, in non-urban settings they tend to prefer interior parts of forest where there is a closed canopy of mast-producing trees, such as oaks and hickories, and where there is a brushy understory. Fox squirrels seem to prefer forest edges and forests with more open canopies and little understory. This difference in habitat preference is not absolute, however, and both species can sometimes be found in the same place. Perhaps fragmentation has altered the environment in small woodlots to such an extent that gray squirrels no longer consider them suitable habitat.

Fox squirrels are slightly larger than gray squirrels, and female fox squirrels defend core areas around their nest sites. Fox squirrels also seem to be able to exploit waste grain in agricultural fields better than gray squirrels. Perhaps these factors, combined with the opening up of forest habitat, have given fox squirrels a competitive edge over gray squirrels, and the presence of fox squirrels prevents gray squirrels from colonizing and maintaining populations in rural woodlots in east-central Illinois.

Finally, gray squirrels and fox squirrels differ in some aspects of their dispersal and predator avoidance behaviors. In non-urban settings, fox squirrels tend to spend more time on the ground than gray squirrels. Fox squirrels may run on the ground for a considerable distance when pursued, whereas gray squirrels more quickly take to the trees. Perhaps these behaviors make fox squirrels better at dispersing over open habitat. In landscapes such as east-central Illinois where wooded patches are often small and isolated, high rates of movements among patches may be required to keep all patches occupied. If gray squirrels are hesitant to disperse across open landscapes, they may not immigrate frequently enough into small woodlots to "rescue" dwindling populations, or recolonize sites quickly after local extirpations.

Such a system, where several small subpopulations occupying different habitat patches are connected by dispersal, is called a metapopulation. If dispersal between the patches becomes disrupted or decreases to a low rate, because of habitat fragmentation for example, the system becomes unstable. If subpopulations in local patches disappear and the patches are not recolonized quickly enough, a species could disappear from a region entirely. Thus, if fox squirrels are better cross-country dispersers than gray squirrels, they could persist in a landscape consisting of small wooded fragments while gray squirrels do not.

To evaluate these three possible mechanisms, we are conducting a series of controlled introductions of radio-collared

Continued on next page

Squirrels

continued from previous page

squirrels. The radio collars allow us to track the fates and movements of the squirrels. If gray squirrels introduced into rural woodlots from which fox squirrels have been removed survive and reproduce, then we can assume that the habitat was suitable and something else was responsible for their absence. If gray squirrels also fail to persist in woodlots where fox squirrels have not been removed, it suggests that competition may be important. If gray squirrels persist in rural woodlots both with and without removal of fox squirrels, it indicates that differences in dispersal abilities may explain the different distributions of these two species. Additional experiments are being conducted to quantify differences in dispersal behavior.

These studies are important for more than just answering questions about squirrels. As humans dominate more and more of the landscape, more and more habitats become fragmented, and the intervening areas may restrict or impede dispersal movements. How different types of plants and animals will respond to this fragmentation is an important concern for conservation biologists and managers. Are dispersal corridors needed for some species? Are there habitat modifications that should be done in the remnant patches to help some species persist? Are there thresholds of isolation (distance between patches) or area (size of patches) that lead to extirpation of some species? It will take the gradual accumulation of information from a variety of species to practically address these questions.

And we'll be able to tell you just why those squirrels in your woodlot or at your bird feeder are gray and white or gray and red.

Photo by Dan Rosenblatt, INHS Center for Wildlife Ecology

Urban gray squirrel on the UI campus.

Dan Rosenblatt and Ed Heske, Center for Wildlife Ecology

Maddox to Retire

Joseph V. Maddox, insect pathologist and Professional Scientist at the Illinois Natural History Survey, is retiring after more than 35 years of service to the state and the discipline of invertebrate pathology.

Joe's interests and influence are far ranging in the world of insect pathogens and biological control of pest insects. His major area of study has been insect pathogenic protozoa, specifically the microsporidia. He has described or characterized several species of microsporidia pathogenic to pest insects, including the gypsy moth, alfalfa weevil, green stink bug, and fall webworm, as well as microsporidian species infecting the purslane sawfly, collembola, and hangingflies. In addition to taxonomic studies, Joe is also a recognized expert on microsporidian epizootiology and biology. He has studied the environmental persistence of the infective spore forms of microsporidia and methods for the long-term storage of these pathogens. His laboratory currently houses the world's largest collection of living microsporidian pathogens.

In addition to his studies of microsporidia, Joe has done extensive work on the epizootiology of entomopathogenic fungi, including pathogens of the European corn borer, potato leafhopper, and alfalfa weevil. He has participated in studies of other pathogen groups including protozoa, other than microsporidia, that are pathogenic to insects and plants, *Bacillus thuringiensis,* and insect viruses. He has also studied the degradation of microbes in soil.

An affiliate with the Department of Entomology at the University of Illinois, Joe taught a graduate-level course in insect pathology and was consistently on the list of excellent teachers at the university. He also taught a summer pathology course associated with the Midwest Biological Control Institute designed to fill deficits in graduate curricula at universities in 12 midwestern states.

Along with his work in the Midwest, Joe has spearheaded international studies of microsporidia pathogenic to pest insects. He studied pathogens of mosquitoes in Pakistan as possible biological control agents and recently has been a major contributor to an international collaboration of European and American scientists in the study of several species of microsporidia pathogenic to the gypsy moth. For these studies on gypsy moth microsporidia, Joe conducted foreign exploration for new isolates of microsporidia in Portugal, Central Europe, and Siberia; prepared species descriptions; studied the biology of the pathogens; participated in release studies; conducted extensive host specificity experiments; and served as consultant to scientists in Austria, Bulgaria, the Czech Republic, Germany, and Slovakia. In addition to these international activities, he currently participates in biological control teaching and exploration programs with the Pan American School of Agriculture in Honduras.

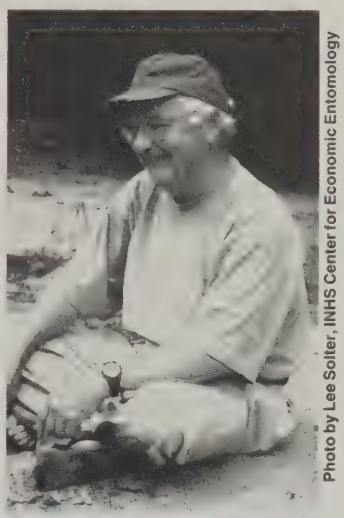


Photo by Lee Solter, INHS Center for Economic Entomology

Joe Maddox at ease in the field.

At the national level, Joe served on the external advisory board for the National Biological Control Institute. He also participated in and edited the proceedings of the National Audubon Society workshop on Host Specificity of Biological Control Agents. He is a much respected member of the Society for Invertebrate Pathology and has held several offices in the society.

A classical insect pathologist with wide-ranging interests, Joe's expertise is sought by scientists in the Midwest as well as other regions in the U.S. and internationally. A measure of the man is the devotion of his students and staff, the trust and admiration of his colleagues, and a constantly ringing telephone. Joe is considered a mentor and a friend by students and colleagues alike. He will be honored with emeritus status at retirement and plans to continue his work in insect pathology.

Colleagues and Friends of Joe Maddox

Species Spotlight

Zebra Swallowtail

Susan Post

If a contest were held to pick the most beautiful butterfly in Illinois, the zebra swallowtail would likely make the final four and perhaps win the coveted title. Zebra swallowtails occur in Illinois from about midway in the state to the southern tip. These inhabitants of moist, shaded woods, however, are far more common in the south. Zebra swallowtails are polymorphic, that is, they have different forms and markings depending on the season. Each spring, small brightly colored examples gracefully dart through sun-dappled woods. The larger and less colorful summer form may be seen just about anytime during the summer season. Zebra swallowtails are not large, as swallowtails go, and have a wingspan of 2.5-4.5 inches. This delicate species is black or dark brown with bright white stripes and a bright red spot at the base. A daggerlike tail graces each hind wing.

Photo by Michael Jeffords, INHS Center for Economic Entomology

Zebra swallowtail, Eurytides marcellus.

When viewed on a pin with wings spread, likely in a budding entomologist's collection, the species appears quite gaudily colored. In its native habitat, though, it is often very difficult to detect because its color pattern helps it elude predators. The same can be said about real zebras in Africa; their color patterns also help to break up their outlines and make them difficult for lions to detect. The zebra swallowtail's black and white stripes blend in remarkably well with the backgrounds present in a sunny woods, and the red spot at the base of its long tails gives predators a false head to aim at, one far removed from the insect's actual head. This increases the swallowtail's chances of surviving a bird attack by 50%.

Adults are nectar feeders and can be seen flitting about on woodland flowers. Adults may also puddle club together—small congregations of zebras often settle on a moist spot in the forest and imbibe nitrogen left by a passing animal. Not only does puddle clubbing help zebras with their nutrition, but the clumps of colorful butterflies, almost always bachelor males, also attract the attention of a passing female.

Zebra swallowtail caterpillars feed on only one species of plant, the leaves of pawpaw, a common understory tree in many Illinois woodlands. Females appear in the forest 2 to 3 weeks before the pawpaw trees leaf out. Once the plants leaf out, the female begins to lay pea-green, spherical eggs on the upper surface of the leaves. The eggs hatch in 7-8 days. The caterpillar is pale green with yellow and black bands across its body. After 3 weeks the caterpillar is fully grown and approximately 2 inches long.

While Illinois' zebras may not be quite as large as their African counterparts, they are every bit as showy, in their own diminutive way, and form a fascinating component of Illinois woodlands.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

What Is an Insect?
Objective: to learn the basic external anatomy of an insect.

Materials: multiple copies of **What Is an Insect?**

Vocabulary: antennae, bilaterally symmetrical, cerci (cercus), ocelli (ocellus), segments, tagmosis

Comments: The basic insect body is a hollow tube made up of segments, and these segments are grouped into three body regions—head, thorax, and abdomen—in a process called *tagmosis* (tagmosis is the clumping together of individual segments to form different body regions that have a particular function). Insects are also *bilaterally symmetrical*, that is, one side is exactly the same as the other side. On the head are a pair of antennae, a pair of compound eyes, and several simple eyes (called ocelli). On the thorax, the locomotory part of the insect, we find three pairs of legs and two pairs of wings. Finally, note that on the rear of the abdomen we have a pair of structures that look like antennae. These are called cerci (singular cercus) and tell the insect what's going on at its other end.

Procedure:
1. Present the above material to students before passing out **What Is an Insect?** or have them try their hands at the diagram with no explanation from you.

2. Go over the completed diagrams as a class and discuss what might be some of the functions carried out by the head (sensory, feeding), thorax (locomotion), and abdomen (digestion, reproduction, respiration).

3. Have students draw an insect that has one or all of the various body parts modified to do different things. For example, have them draw the back legs modified for swimming or the front legs for grasping.

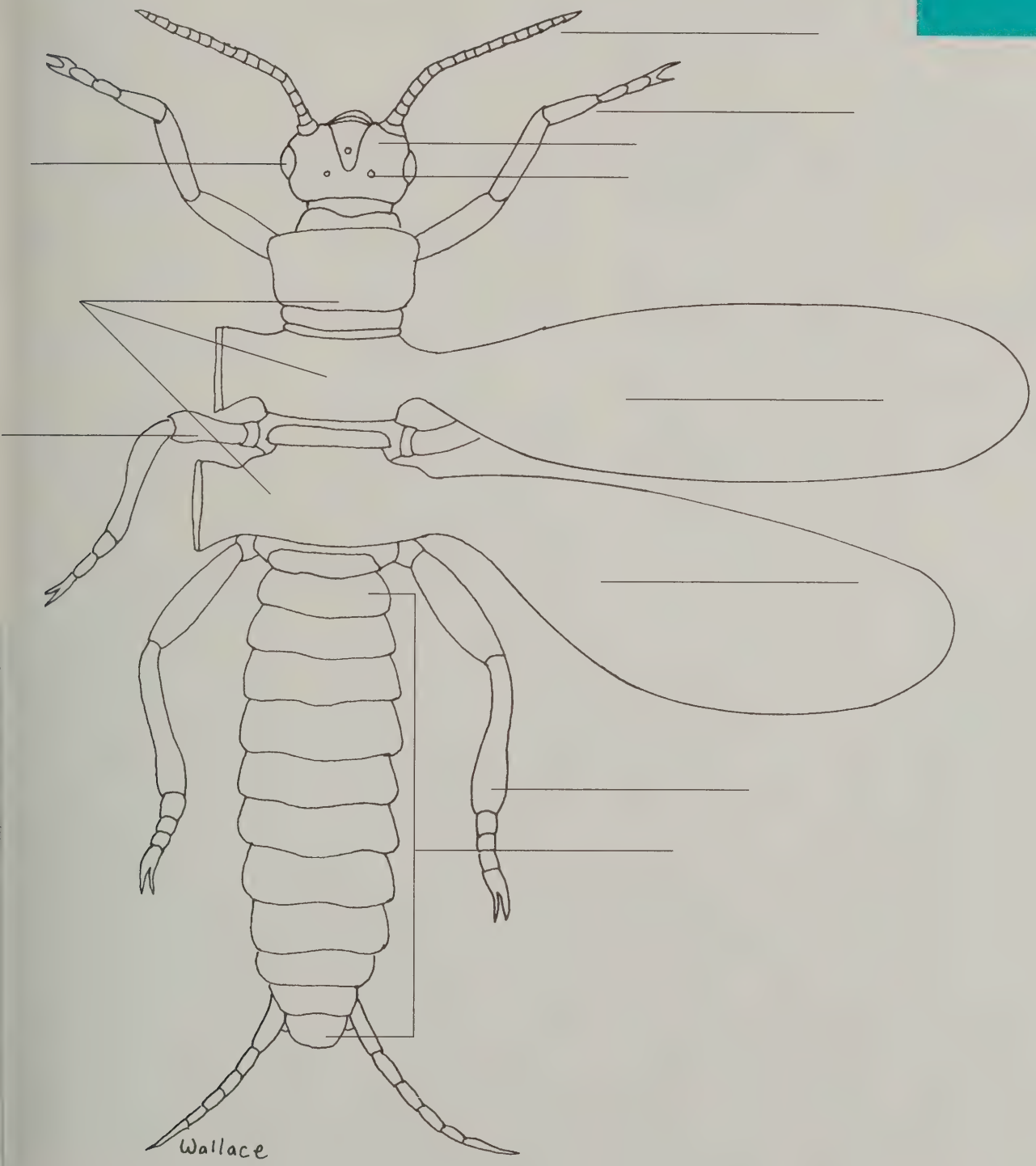
What Is an Insect?

Michael Jeffords

What Is an Insect?

Fill in the blanks on this diagram with the correct names from the list that follows.

abdomen, antenna, cercus, compound eye, foreleg, forewing, head, hindleg, hindwing, middleleg, simple eye (ocellus), thorax



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Stream Sediments

continued from front page

Researchers sampled the benthic macroinvertebrate community at 10 small streams that were hypothesized to vary in sedimentation impacts. At four of the streams, study sites were established upstream and downstream of a potential source of sediment (in all cases a major unpaved road). The three dominant habitats available to macroinvertebrates—soft-bottomed, midchannel areas, stream banks just below the water surface, and woody material (e.g., root snags, submerged logs)—were sampled at all study sites. In addition to these biotic attributes, a variety of physical parameters were measured at each site to characterize conditions in the stream channel and riparian zone.

The four streams with paired study sites upstream and downstream of a potential source of sediment provided strong evidence that excessive sedimentation was occurring in streams on the base. Striking differences in channel morphology and stream bottom characteristics between upstream and downstream sites could only be attributed to excessive sediment inputs. For example, channel slope was 3 to 8-fold greater at the downstream sites. Such increases in slope are easily accounted for by the qualitative balance that is known to occur in stream channels between stream discharge (Q), sediment discharge (Q_s - the mass of sediment moving past a point in the stream per unit time), the median sediment particle size (d_{50}), and stream slope (S): $Q_s\ d_{50} \sim QS$. This relationship indicates that, if all other factors remain constant, an increase in sediment load (Q_s) maintained over a relatively long period of time should result in an increase in slope downstream of the source of sediment. If the left-hand side of the equation does not change (i.e., sediment load and particle size are constant), slope can only increase if discharge decreases, and there were no differences in discharge between upstream and downstream reaches. Upstream and downstream sites also differed in several other important characteristics. Upstream sites were deeper, slower flowing, had bottom sediments comprised largely of silt rather than sand, and had considerably more submersed woody material. Upstream sites appeared to be representative of the "pristine" condition to be expected of small streams in the region. Based on these criteria, the other six streams exhibited varying degrees of excessive sedimentation.

Differences in the structure of the macroinvertebrate community among stream sites were consistent with expectations, based on this physical evidence, that rates of sediment input were substantially elevated at some sites but not others. We observed striking differences among study sites in the number of taxa present; the number of mayfly, stonefly, and caddisfly taxa (insect groups that are relatively sensitive to pollution); and total macroinvertebrate abundance. Two general patterns were evident. First, sites upstream of a main road had significantly greater values for these parameters than sites downstream of the road. Second, two streams, McPherson Creek and Rebel Run, had significantly lower parameter values than all other sampling sites. Physical habitat data suggested that these streams experienced extremely high rates of sediment input.

In most cases, midchannel habitats were more severely impacted by sedimentation than were bank and log habitats. For example, midchannel taxa richness was reduced by over twofold in three out of four downstream sites relative to upstream sites, while taxa richness in the bank and log habitats did not differ between those sites. Midchannel taxa richness was significantly lower in the other six streams than in the upstream sites. The main exception to this pattern was in McPherson Creek and Rebel Run, where all habitat types were adversely affected by sedimentation.

Our results have important implications for the use of biotic criteria in stream monitoring programs. Many monitoring programs focus sampling effort on habitats expected to have the greatest diversity of animals. At Fort Bragg, the bank and wood habitats had by far the greatest biodiversity, even in the relatively pristine sites upstream of sediment sources. Because impacts of sedimentation were greatest in the less diverse, midchannel habitat, these effects would have gone undetected by most monitoring programs. Although we found a diverse and abundant fauna on woody habitat in most streams, the total amount of woody habitat available to macroinvertebrates was severely reduced at sites that experienced excessive sediment inputs. This indicates the importance of assessing the availability of suitable habitat in any attempt to quantify the total impact of sedimentation at a site.

Steven L. Kohler and Daniel A. Soluk, Center for Aquatic Ecology

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ILLINOIS NATURAL HISTORY SURVEY

Reports

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No. 346

INSIDE

On-line List of the Organisms of Illinois

The answer to the question, What animals and plants live in Illinois? is not an easy one. According to one estimate, at least 53,754 organisms are known from Illinois. Some groups (e.g., vertebrates, flowering plants) are well known; others (e.g., insects and fungi) are poorly known. No single location lists all of these organisms. Also, some lists would be exceptionally long!

Because of the biotic surveys that have been completed in Illinois, it is one of the few states that has attempted even to estimate the number of species found within its boundaries. The research of the past century and a half at the Illinois Natural History Survey (INHS) has accumulated in the form of many papers, reports, and carefully documented collections of specimens. However, there has been no single list of the organisms in Illinois either in print or in computer format. Published lists of various groups of organisms, while as complete as the researchers could make them, were by their very nature outdated as soon as they appeared in print. Not only do animals and plants move around as individuals or in the form of seeds and spores, but professional botanists and zoologists also discover new species, and uncover mistakes in naming organisms (nomenclature) that must be corrected. A centralized, easily updated and widely available list of Illinois organisms would be extremely valuable to government agencies, educators, students, farmers, and others with an interest in the state's flora and fauna.

In order to make a summary listing of the organisms of Illinois available to the general public and research community, INHS researchers made a proposal to the former National Biological Service (NBS) to gather the information by taxonomic group and to make it available on the Internet. The primary reason for the project was to help stabilize the names in use for Illinois species of plants and animals and to provide a useful and concise reference for those attempting to work with the Illinois biota.

The partial funding of the database on Illinois organisms resulted in the entry of the best-known (and more "popular") groups of plants and animals into the database followed by lesser-known (and less "popular") groups as time permitted. Two

Continued on back page

Cover-crop Mulches for Alternative Production of Vegetable Crops

We have all seen those idyllic, advertisers' dream pictures of row after row of lush vegetables highlighted crisply against a backdrop of bare earth. But the conventional tillage methods used to produce such crops can increase soil erosion, reduce soil quality, and require extensive amounts of pesticides, fertilizers, and water. Cover crops with reduced tillage have been used in many agricultural systems to reduce soil erosion, improve soil properties, add organic matter, and control weeds. Planted in fall or spring, they are plowed under as a "green manure," left as a killed mulch on the soil before planting the main crop, or grown as a living mulch between rows of the main crop. Vegetable growers have been slower than field-crop producers to adopt such practices because of lack of crop-specific information on the competitiveness, yields, and pest problems associated with these alternative practices.

Photo courtesy of Harry Bottenberg, University of Illinois

Cabbage planted with wood shavings used as an inert mulch.

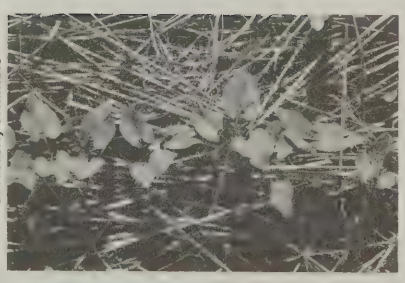


Photo courtesy of Harry Bottenberg, University of Illinois

Snap beans planted with rye mulch.

To address this concern, researchers at the Illinois Natural History Survey and the University of Illinois have been conducting field trials to compare vegetable crops grown in reduced tillage/cover-crop mulch systems with those grown in conventional tillage systems. Because these mulches alter the microclimate of the vegetable crop, the research has also focused on determining whether weed, insect, and disease problems affecting the crop are lessened, or (shudder!) made worse, by these alterations. Snap bean and cabbage were chosen because they are important fresh-market and processing crops in Illinois and represent different plant families with different pest problems. Cereal rye, hairy vetch, perennial ryegrass, and a cereal rye-red clover mixture were tried as cover crops. Cereal rye and hairy vetch were fall-seeded, killed with herbicide or mowing in spring, and left as a mulch on the soil surface. Perennial ryegrass was planted as a living mulch with the vegetable crops, while red clover was overseeded as a living mulch on the killed rye a few weeks before vegetable planting. Vegetables were transplanted (cabbage) or direct-seeded (snap bean) in four- to eight-row plots in late May to early June. A conventional-tillage treatment that involved spring disking and pre-plant herbicide incorporation was included as a control.

To date, fall-planted cereal rye has been the most promising mulch system for weed suppression, but improvements are needed to make vegetable yields more competitive with those of conventional tillage systems. Hairy vetch competed with cabbage and decomposed too quickly to provide adequate weed control. Perennial ryegrass was fairly slow growing, limiting early-season weed control. Vegetable yields in perennial ryegrass plots were fair to good for cabbage, but only fair for snap bean. Clover in the clover-rye treatment competed for moisture with the vegetable crops.

Cabbage grown in cereal rye mulch generally had lower numbers of caterpillar pests and aphids than did plants grown in conventional tillage, but insecticide applications were still required. Cabbage diseases were rare in all trials and did not differ among treatments. Snap bean pod damage from chewing insects tended to be least in conventional tillage and greater in plots with mulches, but conventional tillage plots had greater numbers of sap-feeding pests, such as potato leafhoppers, than did mulch treatments. White mold was more common on snap bean pods in conventional tillage than in mulch treatments.

Current research is focused on improving crop yields with cereal rye mulches and in determining the mechanisms that influence pest problems (positively or negatively) in these systems. Planting vegetables into strip-tilled areas within rye mulch plots has improved yields, and large-plot trials planned for 1997 will continue to refine the usefulness of this cover crop option as an alternative production practice for Illinois vegetable growers.

Cathy Eastman, Center for Economic Entomology, in cooperation with John Masiunas and Harry Bottenberg (Department of Natural Resources and Environmental Sciences) and Darin Eastburn (Department of Crop Sciences), University of Illinois

Differences in Food Consumption and Metabolic Rates Between Walleye Stocks

Distinct fish stocks comprised of one or more populations of the same species can evolve in a variety of ecological conditions. Differences between the stocks are adaptive and can result in different genetic, physiological, anatomical, and life history traits. Thermal regime is one important environmental factor that could influence stock adaptations. Fish from diverse geographical regions may have physiological adaptations to temperature, such as food consumption and metabolic responses that affect growth.

Information about these adaptations between stocks can be used for management decisions. Bioenergetics models are a valuable tool that incorporates food consumption and metabolic parameters as well as information about temperature and fish size to predict growth for a fish population. Resulting growth rates of young-of-the-year fish can be important in determining survival. These models have historically been species-specific rather than stock-specific. We are using a bioenergetics framework for investigating adaptation among fish populations.

Walleye (*Stizostedion vitreum*) are a popular and economically important sportfish that are often maintained by supplemental stockings. These fish are introduced as fry (approximately 9-15 mm) and a range of fingerling sizes (35-100 mm). These walleye are hatchery produced, and parental strains can be from different source populations throughout the country. We investigated physiological differences between stocks by examining growth, food consumption, and metabolic rates of five different genetic stocks of juvenile walleye (100-150 mm) from four different areas throughout North America: Arkansas (two different strains), Missouri, Wisconsin, and northern Canada.

Walleye were held at specific temperatures (5, 10, 15, 20, 25°C) for at least 2 weeks before each experiment. At each temperature, growth and food consumption were measured by holding walleye in individual tanks in a recirculating system at the Illinois Natural History Survey's Kaskaskia Biological Station. The walleye were allowed to feed *ad libitum* on fathead minnows (*Pimephales promelas*) for 2 weeks. Minnows were added to every tank each day of the experiment, and minnows that were not eaten were removed. Weight of minnows consumed was determined as weight of minnows added to the tanks minus the weight of the uneaten minnows. Growth was determined by measuring weights and lengths of the walleye at the beginning and end of the experiment after digestion of the minnows was complete. Metabolic experiments were performed in an environmental chamber kept at a constant temperature (5, 10, 15, 20, or 25°C). Rates were monitored for an individual walleye by recording dissolved oxygen levels before and after an hour of rest in an airtight container.

Overall, relative growth, food consumption, and metabolic rates increased for all stocks with increasing temperature. Relative growth (g. g^{-1}. day^{-1}) was reduced at low temperatures (5°C and 10°C) and showed few differences between stocks. At 15°C, the Wisconsin and Canadian populations grew faster. The Missouri population grew the fastest at 20°C, whereas the southern populations grew faster at 25°C. Food consumption rates followed similar patterns as growth across temperatures. Metabolic rates increased for all stocks with increasing temperature but were variable between stocks.

Physiological differences we observed between stocks, as well as other variations, may have strong implications for conservation of walleye stocks and management of introduced stocks. The stocks with the highest growth rate for a particular temperature varied in relation to their evolutionary thermal regimes. Variation in the growth rates we observed between these stocks should be considered before walleye introductions are conducted. Introduced fish should be from stocks with similar thermal regimes to the recipient reservoir. We will eventually develop bioenergetics models that incorporate these stock-specific relationships among temperature, consumption, and growth to predict growth and survival of introduced walleye.

Photo by David Wahl, INHS Center for Aquatic Ecology

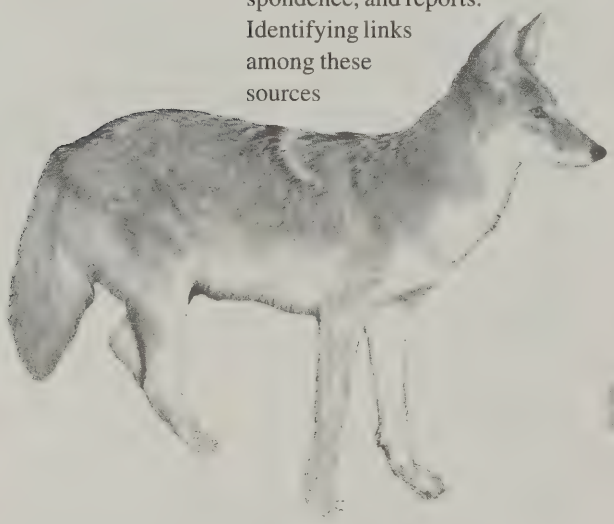
Recirculation system and environmental chamber at INHS Kaskaskia Biological Station measures fish food consumption and metabolic rates.

Tracy Galarowicz and David H. Wahl, Center for Aquatic Ecology

Computer Information System for Wildlife

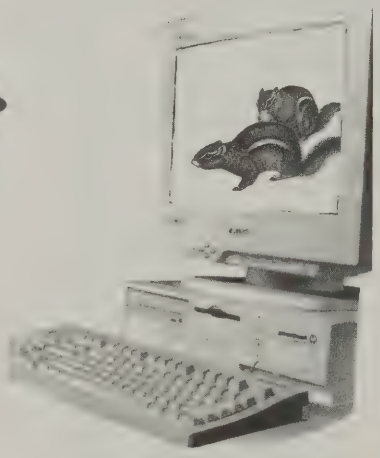
In 1992, the Illinois Natural History Survey's (INHS) Center for Wildlife Ecology and the Illinois Department of Natural Resources (IDNR), Division of Wildlife Resources (DWR), began a cooperative project to develop a computer information system (CIS). The development of such a system is based upon a rigorous systems analysis.

Systems analysis is a process that identifies relationships among different sources of information. For example, within an institution, a person's name may appear in paper forms, database files, correspondence, and reports. Identifying links among these sources



greatly enhances an institution's ability to store, retrieve, and report complex information. Links or relationships are documented on process flowcharts and a database is designed that includes data fields, tables, and indexes. This database design is then compared to the current and future requirements of the system and modifications are made as needed. This process is continuous as data are added, modified, and removed from the database design. When the database design is complete, a database is then created and used for retrieval and management of information.

To date, the focus of system development has been on information within DWR and other subunits of the IDNR. Later enhancements will incorporate information and databases from the Survey. Phase I of the project (now complete) included inventory of hardware, software, existing data files, and data systems. Phase II is ongoing and includes tasks associated with implementation of the design developed in response to the needs addressed in Phase I. The implementation of various applications under Phase II will also include training of staff and additional acquisition of hardware and software.



Analyses completed in Phase I immediately identified the need for a CIS. Most data are stored in stand-alone personal computers or transmitted via paper files through manual processes in the field. Problems associated with data sharing were compounded with the administrative reorganization in 1995 and an expansion by DWR to a more comprehensive approach to habitat and wildlife management.

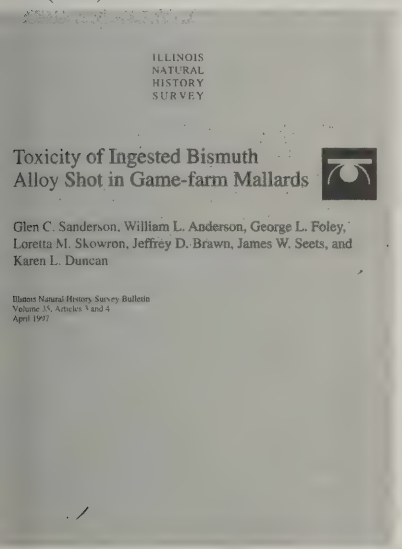
Phase II includes reviews of correspondence, forms, and reports associated with DWR operations and development of a series of flowcharts. Using these flowcharts as a guide to the processes and relationships among data items, a data dictionary has been constructed to create a standard data structure that graphically represents data items and relationships into tables and table interactions. This structure will be used to generate a Standard Query Language (SQL) database. The SQL database will be accessible by staff with an executable file. Users will then have menus to activate data-entry forms and reports based on various wildlife programs and information sources.

A prototype user-access application has been developed and is working with the SQL server. As the project continues to expand, the data dictionary, SQL database, and user-access application will be evaluated and modified. The system will be tested locally and remotely to ensure the CIS integrity. Dial-up access configurations will be addressed with Internet access issues to be explored within a limited scope. Staff will be trained in the use of the system with technical support capabilities. This project will be completed through the coordinated efforts of the Survey, DWR, and the Data Processing Department of IDNR. INHS will be responsible for project coordination and completion.

Jeffrey D. Branham, Lyle W. Wacaser, and Jeffrey D. Brawn, Center for Wildlife Ecology

New Publications and Educational Materials

Sanderson, G.C., W.L. Anderson, G.L. Foley, L.M. Skowron, J.D. Brawn, J.W. Seets, and K.L. Duncan. 1997. Toxicity of ingested bismuth alloy shot in game-farm mallards. Illinois Natural History Survey Bulletin 35(3&4):183-252.



This new bulletin presents two studies on the toxic effects of bismuth alloy shot in mallards. Article 3 of this bulletin describes the methodology and results of a 30-day study on the effects of bismuth alloy and steel shot on game-farm mallards. Article 4 discusses the results of a 150-day study of the effects of bismuth alloy and steel shot on the reproduction and offspring of game-farm mallards.

Price - $10.00 (includes shipping)
To order, send check or money order to:
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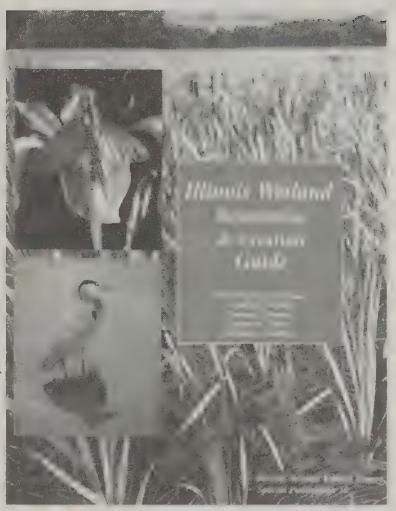
Illinois Natural History Survey
607 E. Peabody Drive
Champaign, IL 61820
phone (217) 333-6880

Admiraal, A.N., M.J. Morris, T.C. Brooks, J.W. Olson, and M.V. Miller. 1997. Illinois wetland restoration and creation guide. Illinois Natural History Survey Special Publication 19. 196 pp.



Follow this practical guide to plan, perform site assessments, design, construct, monitor, and manage restored and newly created wetlands. In addition to step-by-step instructions, this publication contains sample forms, project documents, monitoring plans, management schedules and other items. INHS Special Publication 19 is a must for wetland planners.

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Jeffords, M.R., S.L. Post, R.N. Wiedenmann, and C.S. Sadof. The good guys! Natural enemies of insects. 1997.

Not all the critters in your garden and yard are bad guys. Our newest creation helps you tell the difference between garden insect pests and beneficial insect enemies that actually eat the pests. Now when you encounter the good guys, you'll keep them alive so they can help keep the bad guys at bay without the use of toxic chemicals.

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Price - $8.00 (includes shipping)
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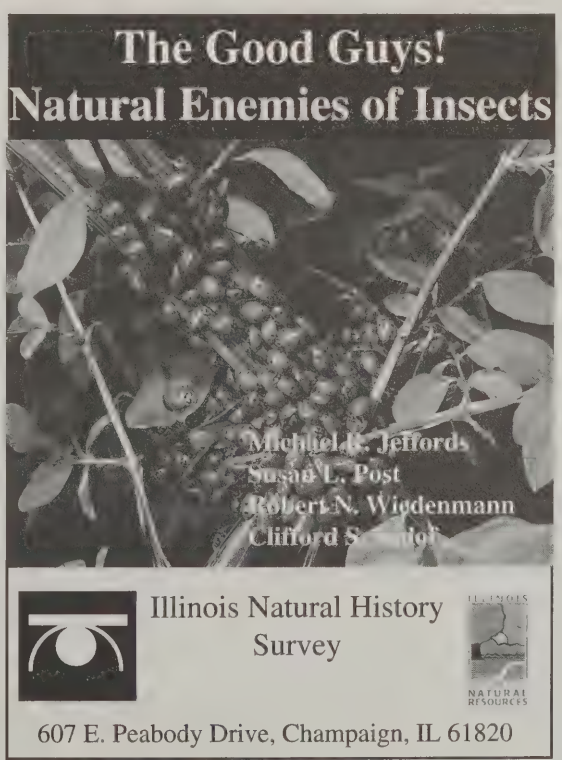


Species Spotlight

American Lotus

Stuart Post

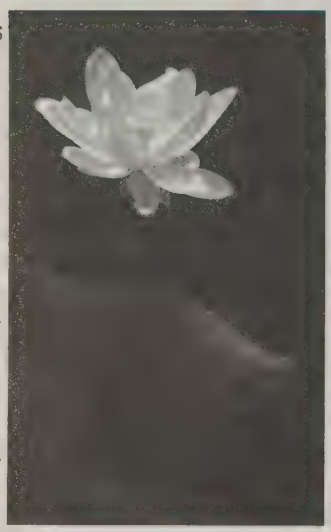


Photo by Michael Jeffords, INHS Center for Economic Entomology

American lotus (Nelumbo lutea)

What do alligator buttons, duck acorns, and rattlenuts have in common? These names, along with water chinquapin, yonkapin, and yockernut, are all common names of the American lotus, *Nelumbo lutea.* Each refers to the plant's round, dark brown, half-inch seeds. Even the plant's genus name glorifies the seeds: *Nelumbo* means "sacred bean." In many cultures the American lotus is sacred and a symbol of beauty.

In Illinois, the American lotus can be found growing along the muddy shores of ponds, quiet streams, or rivers—anywhere it can gain a foothold—from the water's edge to a depth of 8 feet. The quiet backwaters of the Mississippi River, Horseshoe Lake in Alexander County, and Mermet Lake in Massac County are excellent sites to view expanses of American lotus. As many as 8,500 blooms can occur per acre!

The plant propagates itself not only from seed but also from rhizomes and tubers. The rhizomes are stems that creep along the muddy bottom. Tubers are stout and banana-shaped and can reach 10 inches in length and over half a pound in weight.

Late in spring the rolled-up, red-brown leaves push out of the mud. The crinkled leaf slowly opens during the warm days and soon becomes a big leaf platter with a depression in the center where the stem joins from below. The leaves often attain a width of a foot or more. The surface of the leaf sheds water and after a rainstorm the remnant droplets remain in the leaf, like shiny globules of mercury. The leaves either float on the surface or are erect and extend 1-2 feet above the water. By the first frost the leaves grow tattered and brown and slowly sink below the surface.

In early summer, flower buds arise from the same rootstock as the leaves. The flower bud is large and egg-shaped, and encased in several layers of scales and sepals. In Illinois, the flowers begin to bloom in early July and continue throughout the summer. The large, pale yellow flowers rise on stalks higher than the tallest leaves. In the center of each flower is a flat-topped, sulfur-colored receptacle that resembles a salt shaker. This is the pistil, and clustered around it are dozens of yellow stamens.

The flowers open in the morning and, at first, reveal only the female parts. This leads to cross-pollination because the insects that earlier visited older flowers with exposed stamens now crawl over the pistils of the young flowers. Each flower closes at night and lasts only 2 days. After the petals drop off, the center of the flower continues to grow and eventually reaches a diameter of about 3 inches. In the flat top are about 20 holes, each containing a seed. The seedpods bend over and fall into the water where they will rot and release the seeds. In spring some of the seeds will begin to germinate, float to the surface, and be blown ashore. Here, at the water's edge, a rhizome begins growing and a new plant is established—the next generation of the sacred lotus.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Floating Flora and Fauna

Objective: to learn about some of the remarkable adaptations organisms have that enable them to live on the surface of water

Materials: multiple copies of **The Water's Surface**

Vocabulary: predaceous, surface film, surface tension

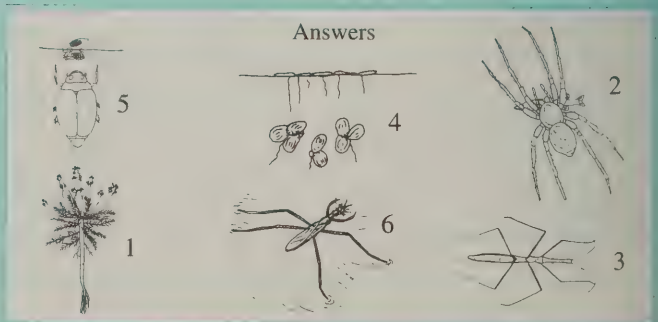
Comments: The surface of a quiet marsh or pond presents no barrier to a raccoon searching for crayfish or a heron attempting to spear an elusive tadpole. To the small creatures of the world, however, the water's surface presents a firm but flexible surface, and many plants and animals are well adapted for living at or near this surface. *Surface tension* results because water molecules are more strongly attracted to each other than to the air above. The surface of the water, therefore, is held in place from each side and from below and results in a dense *surface film* of water molecules. Each of the plants and animals in this activity is adapted in some way for living at or near the water's surface.

Procedure:

1. Pass out copies of the handout **The Water's Surface** to students.

2. Discuss the material in the comments section and ask students to try to match the brief descriptions with the drawings.

3. Go over the correct answers after students have completed the activity and ask if they are aware of any other plants or animals that live on the surface film.



The Water's Surface: A Ceiling for Some, a Floor for Others

Write the number of the description below the picture of the plant or animal it describes.

1. The American featherfoil floats on the surface of quiet waters by means of a spongy, inflated stem. Its feathery leaves are partially submerged or float on or near the water's surface. Small blue flowers occur along the stem. Although the American featherfoil occurs mostly in the southern United States, it ranges north into the Midwest.

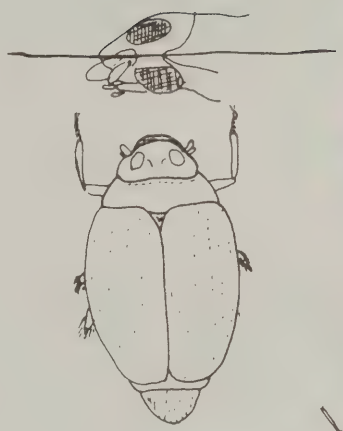
2. Fishing spiders occur along the shores of many wetlands and move about on the water's surface with considerable agility. They feed primarily on animals that have fallen into the water and become trapped in the surface film. Even though these spiders do not spin silken webs, the surface film of the marsh functions as a web.

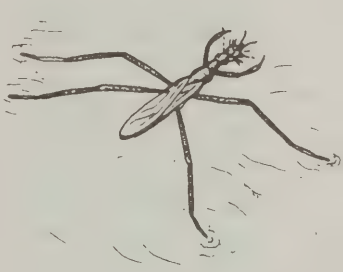
3. Marsh treaders, also called water measurers, are slender, sticklike predators or scavengers that live in vegetation found around the edges of ponds and marshes. Unlike their fast cousins, the water striders, marsh treaders can walk very slowly on the water's surface. As a result, they seem to hunt in slow motion.

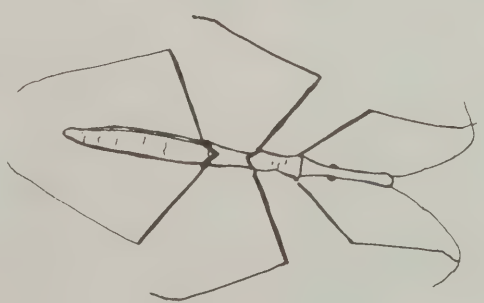
4. Duckweeds are small flowering plants that live on the surface. Tiny rootlets less than half an inch long dangle from the undersides of these plants. Duckweeds reproduce rapidly and can cover the surface of a wetland within a few weeks.

5. The gyrating, spinning whirligig beetles are familiar inhabitants of most quiet waters in the Midwest. Adults are specially adapted for living on the surface film. Their eyes are divided into upper and lower halves—the upper portion sees the world above the water while the lower portion keeps tabs on what's happening below the surface! Whirligigs often congregate in large schools in which they catch small prey or feed on dead organisms. Only the upper half of the beetle is water repellent; thus, it swims half above and half below the surface.

6. The water strider, sometimes called a pond skater, does not float on water like a piece of wood. Instead, it skates along on the surface. Its body is so light that its six legs do not break through the water's thin surface. Tiny waterproof hairs on its feet prevent it from sinking.







ILLINOIS
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HISTORY
SURVEY
607 East Peabody Drive,
Champaign, Illinois
61820 USA

On-line List

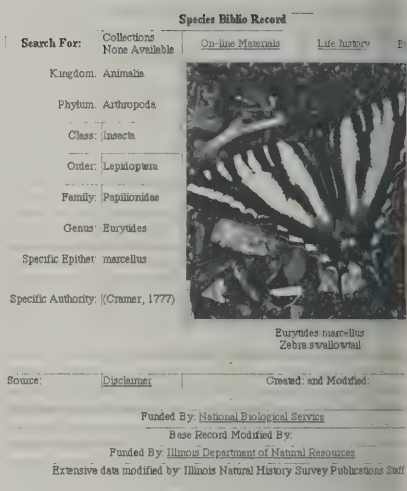
continued from front page

Technical Supportive Scientists assisted in the project, namely Lawrence (Larry) Keller, who updated animal records, and Margaret (Peggy) Waltershausen, who updated plant records. Data were gathered from the Illinois Plant Information Network, the Illinois Fish and Wildlife Information System, current researchers, and published literature.

During the period of funding, over 15,000 individual species records were researched, edited, and entered into a series of databases. Each record had available 25 sets of information, including full scientific name, taxonomic group, synonyms, common names, whether threatened or endangered or not, literature references, whether native or not, and comments. This completed approximately 29% of the estimated total number of organisms in Illinois. This included (among the animals) all of the vertebrate groups (830 species), molluscs (319 species), sponges (12 species), cnidarians (9 species), annelids (164 species), spiders (516 species), and significant numbers of other invertebrates including insects (over 7,000 species entered). Among plants, this includes all known flowering plants (3,046 species), ferns and their relatives (109 species), conifers (22 species), mosses and liverworts (504 species), and algae and diatoms (1,326 species). Groups still awaiting entry include the majority of the fungi, mites, protozoans, bacteria, flatworms, and many more insects.

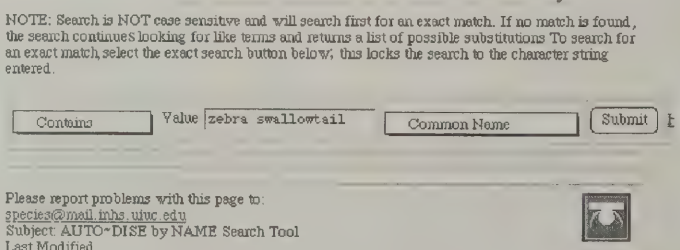
Finally, arrangements were made with INHS computer database managers and network supervisors to coordinate the transfer of the file data to an on-line format available on the Internet. Though the listing is not yet complete, indications from tests of data retrieval by means of Oracle software demonstrate that the project has been a success. The current access address on the Internet to this list of organisms is:
http://ibis.inhs.uiuc.edu:7998/ows-bin/owa/inhs_web.collections

At this location you will find a search engine that will allow you to access bibliographic information on all Illinois species (collections information is not available at this time). Click on "Submit" and a search page will appear. The illustration below shows a view of the search page.



To perform a search, just type in the name of an organism, zebra swallowtail for instance, in the "Value" field and hit the "Submit" button. Notice that the field to the right of the "Value" field reads "Common Name." By pressing this field, a menu appears that allows you to change your search method to any of the choices on the menu; for example, by genus or species instead of common name. In the above illustration you see the result of the search for zebra swallowtail by common name.

Steven R. Hill, Center for Biodiversity



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ILLINOIS NATURAL HISTORY SURVEY

Reports

September/
October 1997
No. 347

INSIDE

Wing Beats Over Illinois

Each spring migrating birds that winter in South and Central America make their way back to breeding sites in North America. Most of these migrants are passerines (perching birds, such as thrushes or warblers) that fly thousands of kilometers before reaching their destinations. Passerines generally migrate at night, and on quiet nights it is possible to hear them calling as they pass high overhead. During the daylight hours between these migratory flights they rest and feed in preparation for the next nocturnal migration.

Migration is a critical time for these birds and many are thought to perish during the trip. Nonetheless, little is known about the natural history of many passerines during the weeks they spend in migration to and from their breeding sites. When in the late evening do migrants take off for a night's migration? What is the specific route these birds take during the night? How high and fast do passerines fly during migration? When and where do they stop for the day? William W. Cochran, a retired INHS scientist, has been instrumental in answering these questions about one group of passerine migrants, the thrushes.

Photo from INHS image archives

A Swainson's Thrush, one of many thrush migrants.

Cochran pioneered monitoring bird behavior using radio telemetry—the remote monitoring of animals fitted with radio transmitters that broadcast audible tones. Investigators extended Cochran's work by attaching tiny radio transmitters to the backs of thrushes (Veeries and Swainson's Thrushes) captured near Urbana, Illinois, in mid-migration. These transmitters produced continuous, not pulsing, audible tones that warbled in response to movement by the thrushes, revealing these birds' migratory behaviors both before and during flight. During daylight hours, erratic warbling in the radio signals indicated the thrushes were moving about the forest vegetation, probably feeding. Later at dusk, just prior to the onset of nocturnal migration, a nonwarbling tone suggested the thrushes had entered a calm period, orienting themselves and assessing conditions for migration. Then after sunset, the thrushes took off, the tones from their transmitters warbling synchronously with the birds' beating wings.

Following a migrating bird in a radio tracking vehicle is challenging. Migrants pushed by strong tailwinds can fly at speeds approaching 60 kph (36 mph) and their paths are not limited by roads. Many birds would have

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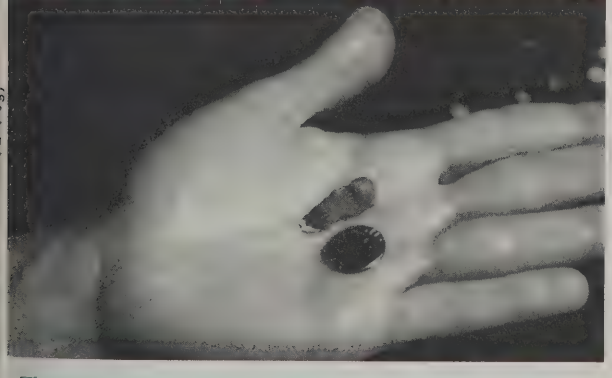


The radio transmitters these thrushes carried weighed about half as much as a dime.

PEET: A Training Effort That is Paying Dividends

Photo by Kevin Holston, INHS Center for Economic Entomology

PEET contigent sifting for therevid larvae in West Cape Province, South Africa.

Systematists, scientists who describe and classify life, have been retiring at a rate greater than they are being replaced, resulting in an ever-dwindling number of trained and active workers. This trend is causing a major crisis in the biological sciences. The crisis is more acute because of the ever-increasing importance of biological diversity in land-use allocation and public policy formulation. Although nearly all of the flowering plants, birds, and mammals are known and described, only about one-fifth to one-tenth of the existing species of most other forms of life are known and described. The very large numbers of undescribed species, including insects, fungi, and bacteria, are important to the functioning of our planet. As such, they need to be described and their ecological relationships better understood.

In an effort to curb this waning of systematists, the National Science Foundation (NSF) recently initiated a program called Partnerships for Enhancing Expertise in Taxonomy, or simply PEET. This program funds projects that train the next generation of systematists, use modern electronic methods to organize and assess data and disseminate results, and target for study the most poorly known groups of biota. Most biological projects funded by NSF last about three years; PEET initiatives last five years. The expanded duration and funding level for PEET projects emphasize the importance and urgency NSF places on increasing the quantity and quality of systematists in the U.S.

The first PEET competition took place in May 1995. Michael E. Irwin of the University of Illinois and Illinois Natural History Survey was among the nearly 100 scientists across the country who took part in that competition. Irwin formed a research partnership with Brian Wiegmann of North Carolina State University, a molecular dipterist; David Yeates of the University of Queensland, Australia, a fly systematist interested in modern methods of classification; F. Christian Thompson of the United States Department of Agriculture's Systematic Entomology Laboratory, a specialist in fly nomenclature; and Donald Webb, a fly systematist, and Gail Kampmeier, an entomologist who specializes in modern electronic databasing and dissemination, both of the Illinois Natural History Survey. This team's proposal focused on stilettoflies, a group of sand-dwelling flies belonging to the dipterous family Therevidae. Irwin and his team successfully garnered 1 of the 21 PEET grants awarded during the first competition. Irwin approached the Schlinger Foundation and obtained supplemental funds to train students and collect and study stilettoflies in remote areas where these flies are unknown but probably extremely diverse and abundant.

Why study stilettoflies? After all, they are small (3-15 mm in length), relatively secretive in nature, infrequently encountered, and, thus, rare in collections. In fact, a scant 840 species in 79 genera are currently recognized worldwide. However, we estimate that between three and four times that number of species actually exists. Stilettofly adults are diurnal; most species imbibe water and a few are known to feed on nectar and plant exudates. The larvae are voracious predators of immature insects that live within sandy soils and leaf litter. The sleek, snakelike larvae move rapidly through such substrates. Because they are abundant in sandy substrates and because they feed on a variety of insects, stilettoflies appear to be critical to the sound functioning of arid and semiarid ecosystems. They appear to provide a balance in maintaining environmental health in fragile, xeric ecosystems, and it is important to assess the separate functional roles of species in natural environments and in those that are managed, such as forest, agriculture, rangeland, and garden ecosystems. The team believes that the richness of adult stilettoflies in a habitat is a good indicator of habitat heterogeneity and that the abundance of individuals is a particularly good measure of subterranean productivity. Furthermore, they believe that stilettoflies should be considered as potential or actual biological control agents because they play an important role in the suppression of pest larvae in sandy agroecosystems.

In all, there are five students currently attached to this PEET grant. Three are with the University of Illinois and the Illinois Natural History Survey: Steve Gaimari, Mark Metz, and Kevin Holston. One, Longlong Yang, is in Wiegmann's lab at North Carolina State University, and another, Shaun Winterton, is in Yeates' lab at the University of Queensland. All are making remarkable progress on various aspects of stilettofly systematics. Progress is also being made on databasing and information dissemination. For more information on this topic, you are invited to log into our Web site at: http://www.in hs.uiuc.edu/cee/wwwtest/therevid/stiletto_fly.html

Michael Irwin and Gail Kampmeier, Center for Economic Entomology

Understanding Large-river Fish Communities

Large floodplain rivers like the Mississippi and Illinois are dynamic and diverse ecosystems. These rivers are composed of several habitats (e.g., main channel, side channel, floodplain, and backwater lakes) that allow a diverse assemblage of organisms to persist. For instance, the Mississippi River supports over 200 fish species from Minnesota to Louisiana. Because floodplain rivers have many specialized habitats, it is often very difficult for researchers to sample river fishes effectively. As a result, scientists understand little about where some river fishes live, what they eat, and how they interact with other members of the river community.

Perhaps the most difficult habitat to sample is the main channel, where current velocities are highest and extensive commercial navigation occurs. Because researchers historically could not effectively sample the main channel, little is known about how many fishes use this potentially inhospitable habitat. Illinois Natural History Survey (INHS) scientists, in collaboration with the U.S. Geological Survey and the U.S. Army Corps of Engineers, are currently sampling fishes in the main channel of the Mississippi and Illinois rivers near their confluence at Grafton, Illinois, with a specialized trawling vessel. This boat pulls trawls (large nets) along the river bottom to collect fishes living in the main channel. At the end of each net haul, Survey researchers identify, measure, and weigh each fish before returning it to the river.

The fish community of the Mississippi River main channel is more diverse than that of the lower Illinois River near Grafton. During 1996, we collected 24 fish species in the Mississippi River, but only 13 species in the Illinois River. This difference is likely due to the larger size and greater habitat complexity of the Mississippi. Freshwater drum, channel catfish, gizzard shad, smallmouth buffalo, and carp were common in trawl catches in both rivers. Fishes typically thought of as large-river species (e.g., shovelnose sturgeon) were abundant only in the Mississippi. We also caught relatively rare river fishes like lake sturgeon and blue sucker only in the Mississippi River.

Photo courtesy of Brian Johnson, U.S. Army Corps of Engineers

Trawling vessel sampling fishes in main channel of Mississippi River.

Some fish, including shovelnose sturgeon, gizzard shad, channel catfish, and smallmouth buffalo, use the main channel during the entire year; these fishes are suited for life in fast-flowing river conditions. Many other fishes use the main channel only seasonally. Our most diverse catches occur in September and October, when river flows typically are lowest and temperatures are moderate. Under these conditions, fish common in backwaters (e.g., bigmouth buffalo, shortnose gar, and black crappie) can be found in the main channel.

Furthermore, fish movements in the main channel may be affected by navigation locks and dams that permit barges to move up and down the Mississippi and Illinois rivers. A lock and dam creates an area for several miles above it that is impounded (creating a more lakelike environment), relative to a free-flowing river. Within each navigation reach, the lower stretch is more lakelike, but the upper stretch more closely resembles a free-flowing, unimpounded river. Our research indicates that some fishes prefer either the free-flowing or impounded areas within a navigation reach for much of the year. For example, blue catfish and bigmouth buffalo occur primarily in the more lakelike part of the main channel. However, species adapted to high river flows (e.g., shovelnose sturgeon, lake sturgeon, and blue sucker) were collected almost exclusively in the more riverine part of the main channel.

By effectively sampling the main channel of large floodplain rivers, we can provide reliable information about the fish community living in this habitat. Fishes occur in the main channel throughout the year, and, especially in the fall, they exhibit high abundance and species diversity. Fish movement and distribution also may be affected by the presence of navigation locks and dams, which provide migration barriers and alter the river for several miles upstream of their location. Continued sampling in the main channel of these diverse ecosystems will allow us to better understand how the entire river functions.

John M. Dettmers, David H. Wahl, and Dan Soluk, Center for Aquatic Ecology

Complex Life-cycle Puzzles

One of the common sights in spring and summer on tree leaves are strangely shaped deformations known as galls. Gall formation by plants happens in response to stimuli caused by a variety of organisms, such as insects, mites, and fungi. Insects can cause galls simply by depositing an egg in leaf tissue, or feeding by larvae or adults may be necessary before the gall begins to develop. Many common galls on trees are caused by aphids, small insects that feed on plants by inserting their tube-like mouthparts into a plant and sucking the plant sap for food. Gall-forming aphids, as do many other gall-forming insects, have complex life cycles as shown by the following examples.

Photo by David Voegtlin, INHS Center for Biodiversity

Galls of K. ulmifusca *on elm leaves.*

Photo by David Voegtlin, INHS Center for Biodiversity

Galls on poplar leaf petioles.

Poplars are host to a group of aphids that cause galls by their feeding (see photo showing three different galls). Visit a large cottonwood tree in the spring or early summer and you will probably be able to find two or three different types of galls. An aphid, hatched from an egg in early spring, begins to feed at a specific point on the leaf or petiole. In response to this feeding the plant grows a hollow, variously shaped gall enclosing the aphid. The aphid matures and produces live offspring until the gall is filled with her daughters, which in turn produce granddaughters that have wings. When the gall matures, openings develop through which these winged aphids escape. These escaping winged adults fly in search of a specific host on which their offspring will be deposited. These so-called secondary or summer hosts are most often herbaceous plants upon which migrating aphids land and then move to the lower stem, where they produce nymphs that follow the root into the soil and begin a colony underground. In the autumn the underground colonies produce a generation of winged aphids that leave the summer host in search of poplars. Here they produce males and oviparous females that mate, and deposit overwintering eggs. Species in this group of aphids often choose cultivated plants on which to spend their summer, and when large aphid populations develop they become pests. Lettuce and sugar beets are two crops in which aphids from poplars are common pests.

Another insect species, *Kaltenbachiella ulmifusca*, forms galls on the leaves of elm trees and was originally named from specimens collected in southern Illinois. Its galls, shown in the accompanying photo, begin forming as soon as the leaves begin to grow. Studies have shown that the gall maker produces anywhere from 3 to 8 nymphs that develop wings and leave as soon as the gall develops an opening. The secondary hosts of this species are in the mint family and successful transfers have been made to bugle weed (*Lycopus virginicus*), a common wetland plant. In autumn, winged aphids leave bugle weed in search of elms, where they give birth to both males and oviparous females. These sexual forms do not feed but undergo several molts, getting progressively smaller, and gather in cracks in the bark where mating occurs. Each mated female produces a single egg that fills her body and she dies with the eggs still inside her.

Complex life cycles are living puzzles to those studying aphids. Most often the aphids that develop in galls look very different from their daughters that develop on roots; these daughters have lost most of their color and other diagnostic features. Experimentally proving that the root aphids found on a herbaceous plant originated from a particular gall is difficult and is usually done by releasing aphids from a gall into an arena of potential host plants. These plants are kept for several months, then dug up and the roots examined for aphids. Ideally these root colonies will produce winged offspring that can be taken back to the host on which the gall developed, and the aphid hatching from the overwintering egg will produce an identical gall. Solving these puzzles is part of the continuing study of aphid biology and taxonomy at INHS.

David Voegtlin, Center for Biodiversity

Waterfowl Research Center Named to Honor Bellrose

The Waterfowl Research Laboratory of INHS' Forbes Biological Station near Havana was officially named the Frank C. Bellrose Waterfowl Research Center during a May 29 reception at Dickson Mounds Museum. The research center will now be recognized for Bellrose's storied career that spans almost 60 years at the station.

Frank C. Bellrose was born in Ottawa, Illinois, on the Illinois River, where he derived his lifelong interest in waterfowl and wetlands. He received his B.S. degree in zoology from the University of Illinois and began working for the Illinois Natural History Survey in 1938. His research included studies on the migration and orientation of waterfowl; dynamics of waterfowl populations; life history, ecology, and management of the wood duck; ecology of aquatic and marsh plants; and ecology of the Illinois River.

Bellrose began a study of wood duck nesting in the late 1930s. Eventually he would develop predator-proof nest boxes. Indeed, the breeding biology, population dynamics of wood ducks, and evaluations of various types of nesting houses became a career-long project for Bellrose. He began a study of the ecology of aquatic, marsh, and moist-soil plants in the bottomland lakes of the Illinois River valley in the summer of 1938 and continued it periodically for more than 40 years. Through this long-term study, the detrimental effects of sedimentation upon the lakes of the Illinois Valley became apparent.

The surveying of waterfowl in the Illinois River valley from the ground with binoculars or spotting scopes was also initiated in 1938. Bellrose began using light aircraft in 1946, and the time required for a comprehensive inventory was greatly reduced while the area covered was noticeably expanded. Waterfowl data derived from these ground and aerial estimates were incorporated into numerous studies. The aerial inventory of waterfowl continues to be an important part of INHS waterfowl research.

The pioneering work on lead poisoning as a mortality factor among waterfowl was one of Bellrose's most important contributions and a major factor in the gradual replacement of lead with nontoxic shot.

Photo courtesy of Illinois Department of Natural Reources

Frank Bellrose (left) and Illinois Department of Natural Resources Director Brent Manning at May reception in Bellrose's honor.

Bellrose's world-renowned book *Ducks, Geese and Swans of North America* was published in 1976 and has sold more than 350,000 copies. His latest book, *Ecology and Management of the Wood Duck*, was published in April 1994. Both of these classics received The Wildlife Society's Publication of the Year Award. Bellrose has published more than 110 scientific and popular articles. His name is virtually synonymous with "ducks."

In recognition of his long and productive career, Western Illinois University, Macomb, awarded Bellrose an honorary Doctor of Science degree in June 1974, as did McMurray College, Jacksonville, in 1995. He received the Aldo Leopold Award, the most prestigious award presented by The Wildlife Society, in 1985. February 1, 1988, was declared "Frank Bellrose Day" in Illinois by Governor James Thompson upon Bellrose's semi-retirement from the Survey. The Alexander-Griswald Marsh, Manitoba, was dedicated to him by the Illinois state organization of Ducks Unlimited in 1982. In 1992, the Illinois Department of Conservation dedicated its Cache River Wetlands Project, which includes the Frank Bellrose Waterfowl Reserve.

His lifelong dedication to waterfowl research has set a high standard. The naming of the Waterfowl Research Laboratory in his honor recognizes the important contribution of Bellrose's work to waterfowl biology and management throughout the world and properly recognizes the Illinois River, where he spent his entire life and professional career.

The Illinois Conservation Foundation is assisting the Waterfowl Research Center in establishing a long-term financial support program. The foundation has set a goal of raising $2 million as a permanent endowment to support the Frank C. Bellrose Waterfowl Research Center. The $2 million endowment will permit the center to continue its high-quality research on waterfowl and wetlands in the state. Interest income generated from the principal will be used to support research studies while allowing for continued growth of the principal investment. Contributors to the center will be permanently recognized on a donor plaque to be placed at the facility. Funds contributed to the foundation are tax-exempt to the fullest extent of the law since the foundation is an IRS 501 (C)(3) approved organization.

For more information on the endowment, contact John Schmitt, Executive Director of the Illinois Conservation Foundation, at (312)814-7237 or (217)785-2003.

Stephen P. Havera, Center for Wildlife Ecology

Species Spotlight

Eastern Mole

Susan Post

For many people, their only experience with moles is Mr. Mole of *Wind in the Willows,* or the all-too-familiar ridgetop trail through their lawns. Because moles seldom venture to the surface, they are seldom seen. In fact, if it weren't for their "sin" of creating ridges in our neatly trimmed and fertilized lawns, moles would likely be held in high esteem and accepted with enthusiasm. They perform such valuable functions as turning over and aerating the soil and consuming that dreaded lawn pest, the "white grub."

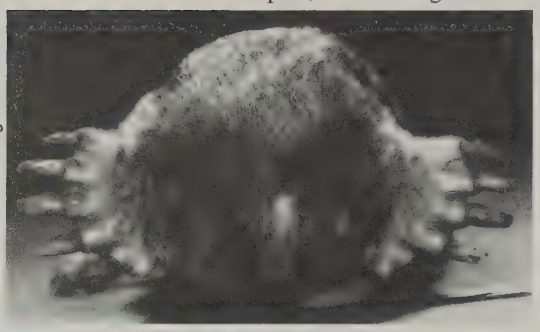


Photo from INHS image archives

The eastern mole. Scalopus aquaticus.

Illinois has a single species of mole, the eastern mole, *Scalopus aquaticus*. This secretive creature is found throughout the state, wherever the soil is friable enough to be pushed upward. The ideal, soft, moist soil, with considerable humus, is usually found in mature and second growth woods, pasture lands, gardens, cemeteries, and lawns. When soil is in good condition, as after a rain, moles can tunnel at a rate of 18 feet per hour.

The mole, with its heavy shoulders, short neck, and stout head, is built for digging underground. Its shovel-like front feet are broader than they are long, equipped with large, heavy claws, and held with their backs toward each other, the palms facing outward. Moles tunnel through the ground using a swimming motion. The forefeet are held close to their pick-shaped snouts and are used to push the dirt aside. The next place for the forefeet to repeat the process is decided upon by the probing snout. Soil is pushed upward with forefeet, not the head. As moles tunnel they search for food—earthworms, insect larvae, millipedes, and centipedes—to satisfy an insatiable appetite. A mole simply overwhelms its prey with little risk of injury or death to itself. It uses powerful forefeet to crush a grub or worm against the tunnel wall. But if the prey does put up a struggle, the mole may simply heap a little dirt on it and bite its head off.

Although moles hear well, they have no external ears to interfere with life in the soil. Their eyes are covered with fused eyelids and can do little more than distinguish between light and dark. The short, blackish fur is plush and will lay flat when stroked from either direction, offering no resistance as a mole moves forward or backward through its tunnel.

Moles are solitary creatures except during the brief spring mating season. In Illinois, this occurs anytime from January to May. Other than this time, moles that meet during their limited travels attack each other and will continue to fight until one retreats or is killed. About 28 to 45 days after breeding the female gives birth to her annual litter, usually four, in a grass-lined nest located 1 to 2 feet below the surface.

Before setting out your next mole trap, take a little time to appreciate these efficient soil engineers. Maybe a few ridges in your lawn aren't so bad after all.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Stream Habitats—Leaf Packs and Surface Film

Objective:
Students will be able to recognize two stream habitats.

Materials:
Leaf Packs: an oblong pan about 1 1/2 inches deep (9" x 13" cake pans work well); a quantity of small stones and twigs; confetti (such as from a paper punch); small paper cups or envelopes to hold the confetti; a soda straw.
The Water's Surface: a clear glass bowl two-thirds full of water; a sewing needle; a straight pin with a large head.

Background Information:
Leaves and twigs fall into a stream from trees along the banks. This material is pushed downstream by the current and tends to accumulate in areas where the current is less strong or where it has become trapped against logs or rocks. These accumulations of leaves are known as leaf packs and provide an abundance of hiding and feeding areas for aquatic invertebrates.

The surface of a quiet marsh or pond presents no barrier to a raccoon searching for crayfish or a heron attempting to spear an elusive tadpole. To the small creatures of the world, however, the water's surface presents a firm but flexible surface, and many plants and animals are well-adapted for living at or near this surface. S*urface tension* occurs because water molecules are more strongly attracted to each other than to the air above. The surface of the water, therefore, is held in place from each side and from below, and this attraction results in a dense *surface film* of water molecules.

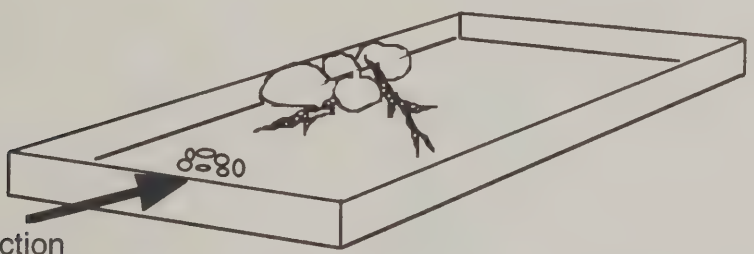
Extending the Activity

If you have the opportunity, take students to a nearby stream and have them attempt to find the two habitats. Examine one or more leaf packs and observe what organisms live in this unusual habitat.

Stream Habitats

To demonstrate a leaf pack:
1. Place a few stones and sticks in a pan, including some piles of stones and sticks along the edges. Place a pile of confetti at one end of the pan and gently blow on it with a straw. The air flow represents flowing water. Blow only in one direction to move the confetti (leaves) down the pan (streambed).

2. The leaves (confetti) will become caught and pile up in areas around the stones and twigs. The confetti does not readily move down the stream and easily becomes caught. If you blow harder, some leaves will break free from the debris and flow by while others will become packed in even more firmly. The packed confetti represents leaf packs, accumulations of fallen leaves and other debris that collect in certain areas of a stream. Leaf packs provide feeding and hiding places for many aquatic macroinvertebrates, and they can be an important habitat in the stream community.



To demonstrate surface tension:
1. Carefully lower a dry needle onto the water's surface. It will float. *Warning: If the needle is wet, or if it is not placed on the surface very carefully, it will sink.* The fact that the metal needle floats on the surface film demonstrates surface tension.

2. Hold a straight pin by its point and push the head against the surface of the water. Observe what happens through the side of the bowl of water. The water dimples down, but if you push too far, the head of the pin will break through the surface, once again allowing the water's surface to become level. As you slowly pull the pin back out, notice that the water sticks to the bottom of the pin and raises up for a short distance before it breaks free from the pin head. This phenomenon also illustrates surface tension.

Answer the following questions:

• What types of adaptations would enable invertebrates or plants to take advantage of the surface tension of water? Sketch some of these designs for surface living.

• What would happen to the animals that live on the surface film of a pond or lake if the water were polluted with soap or other chemicals that altered the surface tension?

ILLINOIS
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61820 USA

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Wing Beats

continued from front page

been lost shortly after takeoff if we were not able to pick-up their transmitters over distances exceeding 10 kilometers (6 miles).

On some nights, thrushes covered more than 450 kilometers (270 miles) on continuous flights lasting over 8 hours. Other flights lasted only a few minutes and may represent the thrushes making exploratory forays into the air column, perhaps testing for appropriate weather conditions at migration altitudes (usually several hundred meters above the ground). In one mysterious 5-minute flight, a Veery took off from a small patch of woods, flew a large circle around our tracking vehicle, and landed in the same patch. Another Veery flew nearly straight west out of Urbana, landing near Springfield, Illinois, 2.5 hours later. Northbound spring migrants do not always fly north!

The special radio transmitters enabled the thrushes' individual wing beats to be counted throughout nocturnal flights. These data are the first of their kind ever collected. It was revealed these thrushes beat their wings about 10 times every second in typical migratory flight and as many as 15 times a second during takeoffs; therefore, an 8-hour thrush flight requires about 300,000 wing beats. These unique wing beat data will help unravel questions about bird flight.

After a night of flight, the thrushes landed in forested habitats to spend daylight hours feeding and resting for the next migratory flight. The importance of conserving forested stopover habitat for migrating passerines was recently highlighted by INHS scientist Scott Robinson (*New York Times,* June 10, 1997). Perhaps apropos of Robinson's conclusions, one Swainson's Thrush was tracked to a tiny forest patch (about 15 m across) among miles of corn stubble, where it spent 3 days before departing on another nocturnal flight. Even the smallest forest fragments may be important to these migrants.

Veery

Robb Diehl and Ron Larkin, Center for Wildlife Ecology

ILLINOIS NATURAL HISTORY SURVEY

Reports

November/
December 1997
No. 348

INSIDE

Mayflies, Stoneflies, and Caddisflies Help Researchers Track Water Quality

Summertime evening strolls along the banks of Illinois rivers and streams provide an opportunity for Illinoisans to encounter aquatic insect adults. The adults of mayflies (Ephemeroptera) and caddisflies (Trichoptera) are the most frequently encountered groups, but the lucky observer may find the more ecologically sensitive stonefly (Plecoptera). Fishermen know these insect orders as the "hatch to match" when choosing or making artificial "flies" to catch a trout or other gamefish. The immatures of these insects live inconspicuously in gravel, on logs, and buried in the mud of large rivers, streams, and lakes. The life cycles of some species last for only several months, but other species must live in the stream for up to several years before changing to the winged adult stage. It is the immature stages of these insects that aquatic biologists use to monitor changes in water quality of streams.

Photo by Denise Stoeckel, INHS Center for Aquatic Ecology

Stonefly larva in stream substrate.

Monitoring of the entire aquatic invertebrate community has been an effective tool for documenting changes in stream health. Recent studies suggest that a subset of sensitive aquatic insects may actually provide information more quickly (and cheaply) than the entire community.

Caddisfly larva.

Photo by Denise Stoeckel, INHS Center for Aquatic Ecology

The EPT index (number of Ephemeroptera, Plecoptera, and Trichoptera species in a sample) is one of the most efficient indices of stream health due to its ease of use and low variability. Its usefulness in monitoring stressed ecosystems has been tested by the addition of insecticides to experimental and control watersheds in the North Carolina Piedmont. Researchers found that EPT values in samples displayed low variability, showed different effects in different stream habitats (leaf packs, moss, sand bottoms), and correlated well with other more costly measures of ecosystem function such as rates of nutrient processing, total invertebrate diversity and biomass, and with the calculation of a biotic index specific to the region.

Photo by Denise Stoeckel, INHS Center for Aquatic Ecology

Mayfly larva.

The Illinois Natural History Survey has been a hotbed of research in the taxonomy, distribution, and ecology of mayflies, stoneflies, and caddisflies throughout the century. Survey entomologists including Barnard D. Burks (mayflies), Theodore H. Frison (stoneflies), and Herbert H. Ross (caddisflies) wrote a large proportion of the original descriptions for North American species during the early and middle part of this century. The original specimens, or types, used to describe those species, and all material collected throughout the careers of Frison, Burks, and Ross, reside in the Survey Insect Collection. Researchers collected the majority of the specimens

Continued on back page

Cowbird Parasitism in Different Habitats

The Brown-headed Cowbird is one of the most abundant, ubiquitous, and widespread birds in North America. Because cowbirds are brood parasites that lay 30 to 80 eggs per season in the nests of other species, their abundance can pose a severe problem for many of their 200 or more host species. In the forests of Illinois, for example, 30-90% of the nests of most migratory songbirds are parasitized, often with more than one cowbird egg. The combination of high levels of nest predation and cowbird parasitism reduces nesting success of many species below levels necessary for population maintenance. This well-publicized phenomenon is the basis for management recommendations aimed at enlarging forest tracts to reduce access to cowbirds, which feed in pastures and row crops rather than in the forest.

When we expanded our studies of songbird nesting success to grasslands and shrublands, we expected to find similar problems with cowbird parasitism. Much to our surprise, however, we found virtually no parasitism in grasslands and low levels of parasitism in some but not all shrubland habitats. Less than 10% of the nests of most grassland species were parasitized across a wide variety of sites including the Midewin National Tallgrass Prairie, Goose Lake State Park, the Des Plaines Conservation Area, Nachusa Grasslands, and the Savannah Army Depot. Shrubland species that do not reject cowbird eggs were heavily parasitized in some sites (e.g., Lake Shelbyville and Middle Fork Wildlife Area), but not in others (e.g., Shawnee National Forest, parts of the old Joliet Army Ammunition Plant). Over 90% of Orchard Oriole (*Icterus spurius*) nests, for example, are parasitized with an average of 2.2 cowbird eggs per nest at Lake Shelbyville, whereas in Shawnee National Forest, less than 40% are parasitized with an average of only one cowbird egg per nest.

These results raise interesting questions for conservation and evolution. Cowbird parasitism is not a major conservation issue for grassland birds in Illinois; parasitism levels are significantly higher near shrubs that cowbirds can use as perches to search for nests, but even near woody vegetation, the majority of nests escape parasitism. Even in grazed grasslands in which cowbirds forage, only a few nests are parasitized. In contrast, the majority of nests of birds in adjacent forest habitats are parasitized.

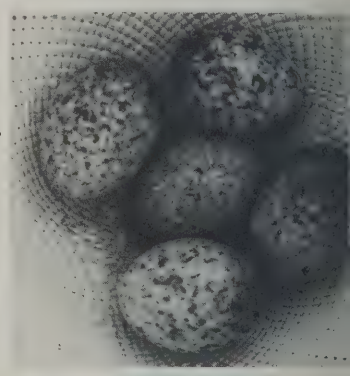


Photo by Dave Enstrom, INHS Center for Biodiversity

Cowbird eggs.

For shrubland birds, parasitism levels appear to vary with the landscape context. In heavily forested landscapes, most shrubland species are parasitized only at moderate levels (10-50%) compared with forest species (30-90%). In landscapes with little forest cover, parasitism levels of shrubland birds are comparable to those in forest habitats.

Why do cowbirds appear to prefer forest hosts over shrubland hosts? Part of the answer may lie in the proportion of hosts in each habitat that have effective defenses against cowbirds. Many shrubland species eject cowbird eggs from their nests (e.g., Gray Catbird, Baltimore Oriole, Warbling Vireo, American Robin, Brown Thrasher), abandon most parasitized nests (e.g., Yellow Warbler, Bell's Vireo, Field Sparrow), or aggressively mob cowbirds that approach their territories (e.g., Eastern Kingbird, Willow Flycatcher, Red-winged Blackbird). Because cowbirds do

Photo by Jeff Hoover, INHS Center for Wildlife Ecology

Mature Brown-headed Cowbird.

Continued on next page

Cowbirds

continued from previous page

not appear to discriminate among these unsuitable and suitable hosts, their nesting success is probably much lower than it is in forest habitats in which none of their hosts have effective defenses. These problems for cowbirds are further exacerbated by the much higher nest predation rates experienced by most shrubland birds compared with their forest counterparts. Cowbirds therefore may avoid shrubland habitats simply because their own eggs have much less chance of producing eggs in shrublands than in forests.

We know much less about the defenses of grassland birds against parasitism, and are just beginning to gather data on predation rates for comparisons with forest habitats. Grasslands with few perches simply may be too difficult for cowbirds to search, especially given the extremely cryptic behavior of grassland birds near their nests.

The high proportion of unsuitable cowbird hosts in shrubland habitats suggests that these open-country hosts have a long co-evolutionary history of coping with cowbirds. The lack of comparable defenses in forest birds suggests a more recent exposure to cowbird parasitism. The evolution of defenses in forest species may be further slowed by the existence of large forest areas in which cowbirds are very rare and host nesting success is high. Any strong selection for host defenses in small woodlots in which nesting success is low and parasitism levels are high may be swamped by excess production of young from areas with little or no cowbird parasitism.

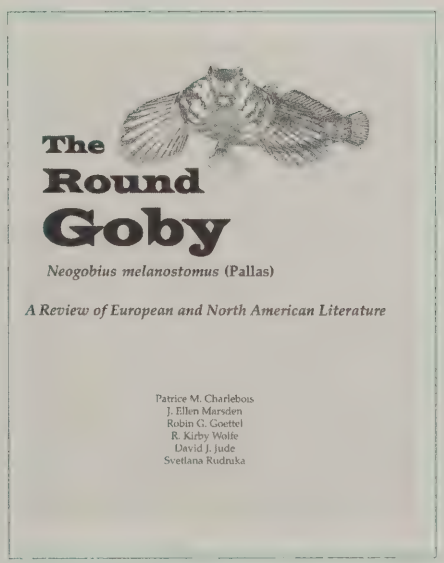
The next steps in our research program are to study the behavior of cowbirds to determine if they avoid shrubland habitats and to determine if grassland hosts have defenses against parasitism. An exciting possibility is that some grassland species may be in the process of evolving defenses against parasitism.

Photo by Dave Enstrom, INHS Center for Biodiversity

Cowbird fledgling.

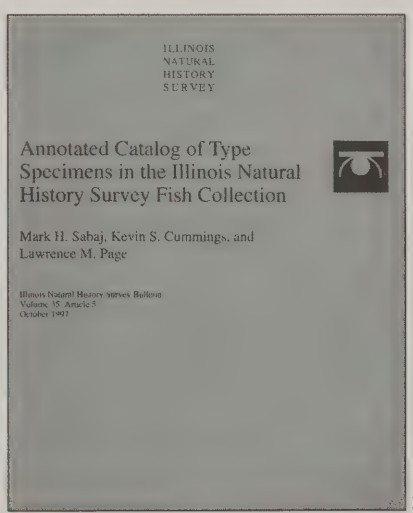
Scott K. Robinson and James L. Herkert, Center for Wildlife Ecology

New Publications



Charlebois, P.M., J.E. Marsden, R.G. Goettel, R.K. Wolfe, D.J. Jude, and S. Rudnika. 1997. The round goby, *Neogobius melanostomus* (Pallas), a review of European and North American literature. Illinois Natural History Survey Special Publication 20. 76 pp. Cost: $5.50 per copy.

Provides a complete review of European and North American literature on this exotic fish that has invaded the Great Lakes. Includes an annotated bibliography and a thorough discussion of the goby's natural history. Published cooperatively by the Illinois/Indiana Sea Grant Program and the Illinois Natural History Survey.



Sabaj, M.H., K.S. Cummings, and L.M. Page. 1997. Annotated catalog of type specimens in the Illinois Natural History Survey fish collection. Illinois Natural History Survey Bulletin 35:5. Cost: $10 per copy. Contains complete diagnostic descriptions of type specimens including photographs of some original material provided by INHS' first chief, Stephen Forbes, in the 1800s.

To order either publication, contact:
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Hydroacoustics: A Tool for Understanding Fish-Habitat Associations in Rivers

Large floodplain rivers, such as the Mississippi and Illinois, are composed of a variety of different habitats (e.g., backwater lake, side channel, main channel). The majority of sampling done to understand the importance of these different habitat types to fish occurs outside the main channel because the main channel has high current velocities and causes most fisheries sampling techniques to be ineffective or too difficult to employ. As a result, present knowledge on fish abundances, species composition, and habitat utilization in the main channel is lacking.

As part of a study on potential effects of commercial navigation of fishes funded by the U.S. Army Corps of Engineers, we are sampling the main channel of the Mississippi and Illinois rivers using a large rockhopper bottom trawl. Our trawl data contradicts existing beliefs that the main channel does not support fishes, instead suggesting that an abundant and diverse fish assemblage exists. Questions such as How do fish survive in high-current velocities that are typical of the main channel? or Where exactly are fish located in the main channel? need to be addressed.

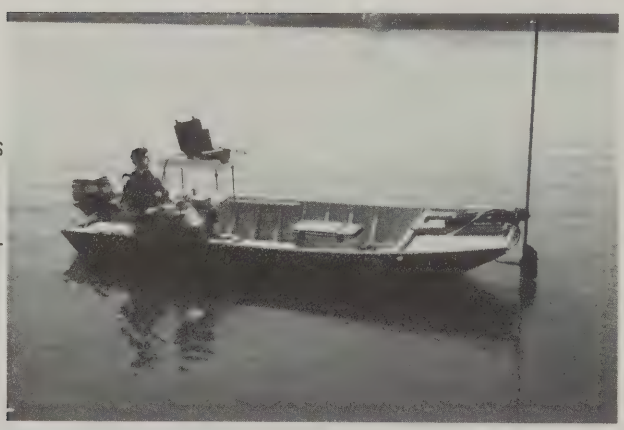


Photo by Randy Claramunt, INHS Center for Aquatic Ecology

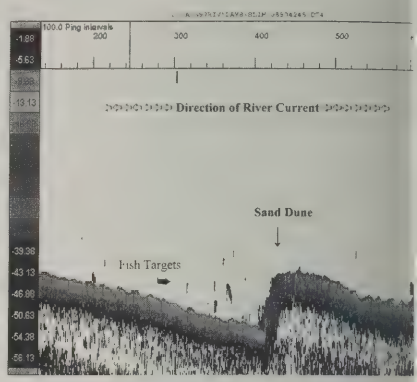
Digital hydroacoustic sampling gear used in the Mississippi and Illinois rivers.

A logical method to address these questions is through the use of hydroacoustics. Hydroacoustic techniques were originally developed for deep marine environments by the U.S. Navy. Recently, methods have been refined so that hydroacoustics are effective for sampling fishes in shallower freshwater systems such as reservoirs and rivers.

Using a digital 200-kHz single beam hydroacoustic system, we hoped to investigate these questions. We sampled sites in the upper and lower section of Navigation Reach 26 of the Mississippi River, and the lower section of the Illinois River where it enters Reach 26. We found a distinct difference in bottom formation and hardness when we compared echograms from the Mississippi River to the Illinois River. The Illinois River bottom has little relief and consists primarily of clay, whereas the Mississippi River bottom consists primarily of sand with strong relief. Sand dunes can be created by high-flow rates when the bottom substrate is mainly sand. These dunes (see figure) are a major part of the Mississippi river bottom and may provide an important refuge from high-flow rates for fish.

To assess the importance of these dunes as main channel fish habitat, we recorded the distribution of each individual fish target in 1.0-meter strata of the water column. Dunes were noted when the river bottom depth contour changed more than 0.3 meters within a distance of 10 meters of bottom. Fish target location was then compared to the location of dunes.

Fish targets were strongly associated with sand dunes in the Mississippi River sites. In almost every case when a dune was located, a fish target was found downstream of its peak. As a result, fish distributions were concentrated and very patchy along the river bottom. Fish targets in the Illinois River were more evenly distributed, both vertically and horizontally, than in the Mississippi River.



Echogram of sand dune with fish targets in the Mississippi River.

Sand dunes may be a critical habitat to species that have adapted to the conditions in large-river systems. For example, the shovelnose sturgeon occurs extensively in the main channel of Reach 26 where flow rates are high but has rarely been collected in the lower Illinois River. If sand dunes are an important habitat for native species such as the sturgeon, further research is needed to assess the abundance of this habitat and how recent changes in the river system (e.g., dams) may have an impact on these habitats.

Randy M. Claramunt, John M. Dettmers, David H. Wahl, and Dan Soluk, Center for Aquatic Ecology

Gypsy Moth in the Chicago Area: Disaster for All or Moderate Problem for Some?

The gypsy moth, *Lymantria dispar,* has a long history of defoliating forests and city trees in the northeastern part of the U.S. In cities, this pest can adversely influence landscape aesthetics, property values, recreation, microclimate, and wildlife. In addition, repeated defoliation by this pest can kill trees. The westward invasion of the gypsy moth is now threatening Indiana and Illinois, with the official front of established populations now in eastern Wisconsin. We wanted to predict potential defoliation to trees in the Chicago area that might occur after the establishment and possible major outbreak of this pest.

Our procedure for estimating the impact of a gypsy moth outbreak on urban trees involved three major steps. First, the number of trees and amount of leaves for each tree species were determined. Second, each tree species was classified according to its attractiveness to or probability of infestation by gypsy moth. Third, a model for defoliation, summer refoliation, and mortality was developed based on published information and the data described above.

According to our calculations, the potential defoliation by gypsy moth in the Chicago area is relatively modest, ranging from 14% in Chicago and suburban Cook County to 26% in DuPage County. Localized defoliation can be higher, however, particularly on institutional lands dominated by vegetation (e.g., parks, cemeteries, golf courses) and on vacant lands where defoliation estimates range between 23% and 40%. On these lands there is a high proportion of tree species that are highly vulnerable to gypsy moth. Note, however, that less than one-tenth of one percent of the total number of trees in the entire Chicago area are predicted to die because of gypsy moth defoliation during a two-year outbreak.

Another area of particular concern is residential lands, which contain most of the tree leaves in the Chicago area. Estimated defoliation in residential areas is highest in the most rural area, DuPage County (20%), and relatively low in Chicago (6%) and suburban Cook County (3%). Potential for gypsy moth defoliation is generally highest in the more rural areas and on land where trees remain in a more natural setting.

We concluded that when the gypsy moth becomes established in the Chicago area, outbreaks are not likely to cause large-scale problems requiring city- or countywide action. However, local controls may be necessary on vacant land, institutional lands (e.g., parks, cemeteries, golf courses), and residential lands, particularly in DuPage County, and in forest stands with high usage or visibility. Park and forest preserve districts may want to develop plans for managing gypsy moth in areas with high percentages of preferred hosts. In addition, because individual residential trees can be defoliated, education programs should be developed to inform homeowners about trunk banding and other cultural, microbial, or chemical techniques to control gypsy moth larvae.

David W. Onstad and Michael R. Jeffords, Center for Economic Entomology

A

B

C

D

A. Gypsy moth larvae congregating during the day on a tree.

B. Pupal skin that has been cast off next to part of egg mass.

C. Mature gypsy moth larva.

D. Female and male (smaller body) gypsy moth pupae.

Photos by Michael Jeffords, INHS Center for Economic Entomology

Species Spotlight

The Sycamore

Susan Post

In presettlement days, the eastern border of Illinois contained the great trees that made up the last stronghold of the eastern deciduous forest. Some considered them to be one of the wonders of the world. The trees grew to prodigious size, and among the giants were the sycamores. These old sycamores had great white branches as large as tree trunks—stark pale ghosts of perhaps even larger trees before them. The sycamores are, in girth of trunk, the largest deciduous hardwoods of North America, and in those early days were truly the giants of the earth.

Photo by Michael Jeffords, INHS Center for Economic Entomology

A sycamore, Plantanus occidentalis.

Sycamore, *Plantanus occidentalis*, is a tree of bottomlands and is found throughout Illinois. Sycamores are characterized by light gray outer bark that scales away like "torn wallpaper" to reveal an inner white bark. In moonlight, these white branches and trunks stand out starkly and marked the river's edge for early navigators. The leaves, which are broader than long and frequently 10 inches wide, are among the largest of the simple native leaves. They are arranged alternately on the twigs and are bright green above and paler beneath. In the fall they turn a russet brown.

The tree produces both its leaves and flowers in May. The flowers grow in inconspicuous, drooping, dense clusters. The fruits which soon appear are greenish balls suspended from slender stems. The fruits were the favorite food of the now extinct Carolina paraquet. By October, the fruits have matured and are dangling brown balls of seeds about an inch in diameter. They will remain on the tree most of the winter, and by spring will break up into fluff, scattering the fine seeds into the wind. These fruits lend the common names buttonwood and button-ball tree to the sycamore.

Once sycamores reach middle age (200 to 300 years old) they become hollow. The sapwood is no longer involved with water and mineral transport, but instead, gradually fills with metabolic wastes and resins that harden to form the dead central core of the tree, known as heartwood. When the heartwood rots, which frequently happens with sycamores, the tree is hollow, yet can still live a long life.

One of the largest trees to exist between the Allegheny and Rocky mountains was a sycamore that stood on the banks of Coffee Creek, about four miles below Mt. Carmel in Wabash County. This giant stood 168 feet tall with a diameter of 16 feet! The area underneath its branches became a popular picnic spot, and its hollow trunk provided shelter during rain. By 1897 the landowner had had enough of curiosity seekers trampling his crops in nearby fields, and had the tree cut. No part of it remains today, but in the Red Barn Nature Center of Beall Woods State Park, one can view photographs of this past giant and stand in a large circle (illustrating its circumference and diameter) painted on the floor—the last representation of this great tree.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Big Trees!

Objective: to discover some of Illinois' largest trees

Materials: multiple copies of **Big Trees!**

Vocabulary: circumference, diameter at breast height (dbh)

Comments: When most individuals think of big trees, the giant redwoods or sequoias of California are the first to come to mind. Illinois, however, has its share of large trees, and this addition of The Naturalist's Apprentice will have students calculate just how big some of these giants really are. Foresters and other individuals interested in knowing tree size usually use a measurement called diameter at breast height, or dbh. This measurement is usually taken about 52 inches from the ground surface. Currently, Illinois' largest tree is a bald cypress in the Cache River lowlands of southern Illinois.

Procedure:

1. Give each student a copy of the handout **Big Trees!** They must use the information found there to calculate the dbh of the trees given.

2. The correct formula for calculating dbh from the circumference is $D = C/\pi$ where D = diameter, C = circumference, $\pi = 3.14$.

The Naturalist's Apprentice

Big Trees!

Michael Jeffords

Big Trees!

Use the information given below to calculate the diameter of some of Illinois' largest trees. You should use the formula $C = \pi D$ for your calculations. (Hint: you must rearrange the formula to find D.)

Species	County	Circumference	Diameter
Sugar Maple	Menard	17'5"	
Pecan	Wabash	12'5"	
Mockernut Hickory	Wabash	8'	
Eastern Redbud	Moultrie	6'8.5"	
Flowering Dogwood	Jefferson	5'3"	
Black Walnut	Cass	16'1"	
Eastern Red Cedar	Bureau	9'1"	
Hophornbeam	Christian	7'7.5"	
Sycamore	Logan	23'	
White Oak	Putnam	20'	
Shingle Oak	Wabash	13'1"	
Shumard Oak	Wayne	17'2.5"	
Baldcypress	Pulaski	34'3"	
American Basswood	Kankakee	15'3"	

ILLINOIS
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Water Quality

continued from front page

before the most severe environmental degradation took place. Consequently, they represent irreplaceable and irrefutable proof that species occurred in areas throughout the state and region. Efforts are currently under way to database all these specimen records to make the data more accessible for aquatic entomologists, pollution biologists, and other government agencies needing this type of information. A database containing records of all stoneflies (>17,000 records) in the Survey collection facilitated Dr. Donald W. Webb's efforts to establish imperilment status for several rare Illinois species. These and other databases may be visited at the Survey homepage (http://www.inhs.uiuc.edu).

A new statewide monitoring effort, the Critical Trends Assessment Project (CTAP), has begun to monitor the quality and biodiversity of streams, forest patches, prairie remnants, and wetlands in the state. The author is presently monitoring trends in stream health by using EPT species, water chemistry, and habitat quality characteristics. CTAP randomly chose 30 sites this year from across the state to provide an average look at water quality of wadable streams. The fieldwork is complete, with identification and data analysis to follow. At least 120 randomly chosen sites will be sampled over the next four-year period. Resurvey efforts follow a five-year rotation. Some streams drain several landowner partnerships in the state. Landowners in these partnerships institute some best management practices with the help of local and state agencies. Hopefully, these practices will lead to a healthier environment. The ability to make comparisons with historical collections (using insect collections databases) will add another dimension to this project.

The author and his colleagues currently work on several other Survey projects involving EPT species. Reassessment of Illinois summer-emerging stoneflies is a priority. Many large species no longer occur in locations where they historically resided. Ultraviolet light trap collections of adult EPT species, a project funded by the U.S. Geological Survey, provide information on water quality in the lower Illinois River basin. Additionally, The Nature Conservancy funds a search for an Illinois endemic stonefly not collected since 1860.

Dr. R. Edward DeWalt, Center for Biodiversity

ILLINOIS NATURAL HISTORY SURVEY

Reports

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February 1998
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INSIDE

"...David Thomas is a demonstrated leader who takes a broad view of issues and an interdisciplinary approach to solving problems..."

David L. Thomas New Chief of INHS

The Board of Natural Resources and Conservation appointed David L. Thomas, Director of the Illinois Waste Management and Research Center (WMRC), as the new Chief of the Illinois Natural History Survey (INHS), Board Chairman Brent Manning announced in November.

Dr. Thomas began his duties at INHS on December 1. He replaces Dr. Lorin Nevling, who retired last year.

"The Board and I believe David Thomas is a demonstrated leader who takes a broad view of issues and an interdisciplinary approach to solving problems," Manning said. "His extensive experience ranging from environmental consulting, solving real-time problems for industry, leading the Waste Management and Research Center, and maintaining his strong interest in ecology and sustainable development make him ideally suited to lead the Natural History Survey into the twenty-first century."

Manning added, "He has led the Illinois Waste Management and Research Center from its infancy and developed it into a national leader in pollution prevention and waste management."

Thomas directed the WMRC for the last 12 years. He has a bachelor of science degree in zoology from the University of Illinois, and a master's degree in ecology also from the University of Illinois. His doctorate was in ecology and systematics from Cornell University. His master's thesis was on the life history of *Percina* darters of the Kaskaskia River, and was done as part of a larger investigation of the river by the Illinois Natural History Survey. His Ph.D. thesis was a comparative ecological study of six species of drums (Sciaenidae) of the Delaware River estuary.

Thomas was an INHS staff member during the 1960s, is a certified fisheries scientist with the American Fisheries Society, and has held memberships in the Federation of Research Biologists, American Association for the Advancement of Science, and the Society of Icthyologists and Herpetologists.

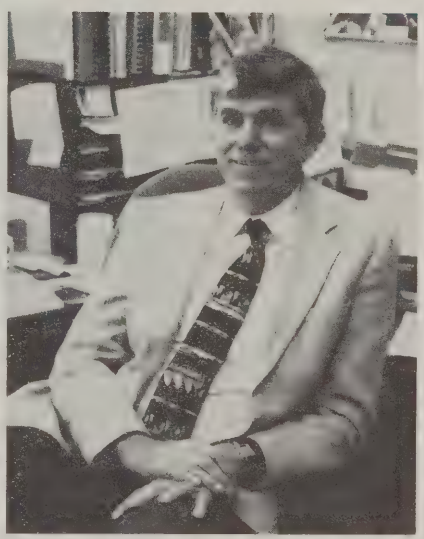

Photo courtesy of Illinois Waste Management and Research Center

From 1970 through early 1985, Dr. Thomas worked for two environmental consulting firms and a Boston-based architect engineering firm. He directed environmental studies for a number of major projects, including the first proposed floating nuclear plant, the Oyster Creek Nuclear Station, the Department of Energy's proposed Ocean Thermal Energy Conversion program, pumped storage plants in upstate New York, a larger water supply reservoir in New Jersey, and numerous transmission line projects.

From May 1985 through November 1997, Dr. Thomas was the Director of the Illinois Waste Management and Research Center, which is a division within the Illinois Department of Natural Resources. He oversaw all the Center's activities, including the following programs: pollution prevention, research and laboratory services, information, and data management. He also coordinated the planning and development of the Center's $9-million Hazardous Materials Laboratory, a state-of-the-art research facility located at the University of Illinois in Urbana-Champaign.

Dr. Thomas has been active both nationally and internationally in the area of pollution prevention and sustainable development. He was on the first advisory board of the National Pollution Prevention Roundtable from 1990 to 1994 and was chair of the roundtable's board of directors from October 1993 to September 1994. He represented the roundtable on the Environmental Protection Agency's American Institute for Pollution Prevention from 1992 through 1996, and was on the institute's executive committee beginning in August 1993. He has worked with numerous countries, including Brazil, Egypt, Thailand, and Malaysia, to develop pollution prevention and cleaner production programs.

Illinois Corn Cob a Weapon Against Pests

Integrated pest management (IPM) in Illinois is faced with numerous challenges. New pests, like the Asian tiger mosquito, a potential vector of numerous mosquito-borne diseases, were introduced into the state. Also, the pests that have been around for awhile are adapting to pest management practices; for example, the western corn rootworm thrives despite crop rotation practices, and many insect pests develop genetic resistance to synthetic pesticides.

These problems and the commitment of society and government to the reduction of the amount of insecticides applied in urban and agricultural environments challenge our scientific capabilities to develop innovative pest management strategies that meet environmental goals while continuing the productivity of American agriculture. A potential weapon against insect pests of public health and agriculture includes the use of an abundant Illinois crop by-product—the corn cob.

Corn cob granules can be formulated with small dosages of chemical and microbial insecticides, insect behavior-modifying chemicals (attractants and feeding stimulants), and a variety of insect pathogens (viruses, bacteria, fungi, and microsporidia). Granules can provide a variety of desirable characteristics, including a high degree of target specificity, short- or long-term persistence, delayed release of active ingredients, and a substantial reduction in the amount of insecticide used in the environment.

In the mid-1970s, corn cob granules were appraised as a possible carrier of insecticides for mosquito control. Corn cobs were ground into particles ranging in size from 6 to 14 mesh that were able to penetrate both primary and secondary vegetative canopies. This was an important attribute because the aquatic habitats that produce mosquitoes include both wooded areas and open grassy sites. Efficiency of control, as well as the cost of application, are both optimized if as much of the insecticide as possible is delivered to the target organism with minimal environmental contamination or drift.

Waste tire dumps are a major source of mosquito habitat for over a dozen pest and vector mosquito species. This includes the vectors of two mosquito-borne diseases that have plagued Illinois, St. Louis encephalitis and LaCrosse encephalitis. One of the main difficulties in treating large tire piles is the even dispersal of granules throughout the entire tire pile. Treatment of tires with liquid formulations is often problematic because of extensive runoff and poor penetration of interior tires. Cooperative experiments by the Medical Entomology Program of INHS, the Illinois and Chicago Departments of Public Health, and a commercial collaborator, Clarke Outdoor Spray Co., found that synthetic and microbial insecticides incorporated into the corn cob granules exhibited two important characteristics: a high degree of penetration into variously stacked tire piles and the slow release of toxicant, thus increasing efficacy and prolong-

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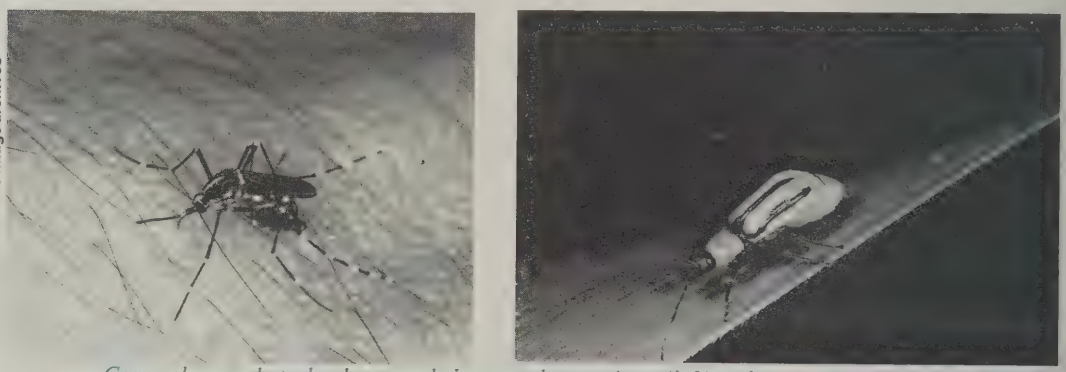
Photos from INHS image archives



Corn cob granule technology can help control mosquitoes (left) and western corn rootworms.

> The corn cob was instrumental in providing not only a means of reaching "hidden" mosquito larval habitats but also provided environmentally safe, long-term control.

Corn Cob

continued from previous page

ing the period of activity. The corn cob was instrumental in providing not only a means of reaching "hidden" mosquito larval habitats but also provided environmentally safe, long-term control.

The technology developed for mosquito control also has great potential to address a wide range of insect pest problems, such as the management of corn rootworms. *Diabrotica barberi* (the northern corn rootworm) and *Diabrotica virgifera virgifera* (the western corn rootworm) are the most expensive insect pests in Illinois with annual crop losses and treatment costs estimated at $100 million. Present control practices for corn rootworms based on crop rotations of corn and soybeans and the application of soil insecticides in continuous corn are frequently less than satisfactory. Changes in rootworm behavior threaten the use of crop rotation, and variable environmental factors, such as temperature and precipitation, can greatly reduce the efficacy of soil insecticides. Furthermore, the broad use of synthetic pesticides has introduced many new problems, including insecticide resistance, microbial degradation of insecticides, the elimination of beneficial insects, the emergence of secondary pests, acute toxicity to applicators, and environmental contamination resulting in pesticide residues in humans and wildlife. These are major reasons for exploring alternative pest management techniques that reduce the application rates of insecticide in the environment.

Extensive research is being focused on the use of baits directed at suppressing adult corn rootworm populations prior to mating and oviposition. The bait technology, combining rootworm feeding stimulants, volatile attractants, and insecticides with various carriers, was originally developed at the University of Illinois. Cucurbitacin and insecticide formulations on corn granules and dried hybrid squash produced high beetle mortalities when aerially applied at about 10 kg per ha. The total amount of insecticide applied was dramatically reduced by at least 90% over soil applications, about 30 grams of insecticide per ha, and the feeding stimulant content (cucurbitacins) was only about 1 gram per ha. Field tests in Illinois indicated the bait was highly specific for corn rootworms with little impact on predators.

Research progress with granular technology has been hampered by the lack of a simple applicator to disperse the granules in relatively broad swaths. Aerial application is relatively costly and requires specialized equipment for bait application. Backpack sprayers are considerably more effective than hand distribution, but generally only disperse granules over 10 to 20 meters. Recently, a new application method, the Aero-Gun™, was developed that allows the precise, even coverage with corn cob granules of an area of over 30 meters and a lateral pattern varying from 5 to 10 meters. The entire unit is mounted on a trailer and granules can be applied while the vehicle is stationary or in motion.

Preliminary results on the distribution of granules from the Aero-Gun indicate this equipment may be used in a variety of future studies on the control of floodwater and container mosquitoes as well as corn rootworms and other agricultural pests.

Photo courtesy of Elaine R. Metcalf

Aero-Gun™ applicator mounted on trailer.

Richard Lampman and Robert Novak, INHS Medical Entomology Program; Robert Metcalf, INHS and University of Illinois, and Hans Hummel, University of Geissen, Germany

Insects and Fire: Too Much of a Good Thing?

Insects comprise the largest component of biodiversity in native prairies, where they play a variety of important roles, including being the major pollinators of native plants. Thus, management that maintains a diverse insect fauna is crucial to the conservation of these ecosystems. Traditionally, managers have relied heavily on prescribed fire to encourage production and flowering of native grasses and forbs, and to discourage growth of woody and invasive species. Although this method has had a dramatic, positive impact on native plant diversity and structure in prairies, many entomologists question the assumption that prairie insects are adapted to fire and, thus, are not harmed by prescribed burns. Anecdotal reports suggest that fire reduces insect abundance, species richness, and diversity, but more detailed studies have revealed that some species recover quickly from fire. Nevertheless, the subject of the effects of fire on prairie insects remains controversial, in part because the factors that determine the rate of recovery of insect populations after fire are not well understood.

Photo by Christopher Dietrich, INHS Center for Biodiversity

Mary Harper and Rick Larimore record the vegetative cover in an insect enclosure at Richardson Wildlife Foundation.

Post-burn recovery results from a combination of recolonization and in situ survival, the relative importance of which remains unknown, and apparently varies depending on burn characteristics and the proximity of unburned refugia. Insect diversity in prairie remnants could be managed more effectively if we knew whether and under what conditions insects survive fire in situ. If in situ survival is rare, then maintaining unburned refugia nearby is necessary to enable insects to recolonize a burned site.

In a study currently under way, we are attempting to assess the relative contributions of recolonization and in situ survival to overall post-fire recovery of insect populations by monitoring the insect faunas of two Illinois remnant prairies—Richardson Wildlife Foundation in Lee County and Windfall Prairie in Vermilion County—following prescribed burns. Following a spring burn, each prairie was divided into burned and unburned units and equal numbers of enclosed and unenclosed plots were monitored in each unit throughout the growing season. Insects found within the enclosures, constructed of "no-see-um" netting, presumably survived the fire in situ. Those found in the unenclosed plots either survived in situ or recolonized the site from elsewhere. By comparing the faunas of burned and unburned and enclosed and unenclosed plots, we were able to assess the contributions of in situ survival versus recolonization to overall recovery of insect populations.

Results of this first year of monitoring suggest that although fire is not necessarily detrimental to insect species richness, prescribed burns can have a significant impact on species composition, primarily because certain species do not normally survive fire in situ. At both sites, although overall species diversity in both enclosed and unenclosed plots was initially reduced as a result of the fire, by the end of July no significant differences in diversity were found between the burned and unburned treatments. Some species extirpated by fire quickly recolonized the burned areas, seemingly from adjacent unburned refugia. At Windfall Prairie, *Laevicephalus minimus*, a leafhopper that specializes on side-oats grama, was initially absent from the burned unit, but adult individuals began showing up in the uncaged plots by mid-June, apparently having migrated from the unburned part of the prairie. Other less mobile species failed to appear despite an abundance of suitable host plants. The grass-feeding aphid, *Izyphia flabella*, was abundant in the unburned plots but remained absent from the burned plots, and probably will require more than a single season to recolonize the burned area. This suggests that differences in species composition between burned and unburned treatments resulted because some species not only failed to survive in situ but also were unable to recolonize the burned area.

This study repesents a preliminary step towards a greater understanding of the effects of fire on prairie insects. Analyses of additional data on vegetation, burn temperature, and burn intensity will address additional unanswered questions crucial to our understanding of the effects of fire on prairie insects. Hopefully, as more data become available in subsequent years, consistent patterns will begin to emerge that will enable us to make specific recommendations for managing insect diversity in native prairies.

C.H. Dietrich, Center for Biodiversity; M.G. Harper, R.L. Larimore, and P.A. Tessene, Center for Wildlife Ecology

Fire, Savanna Restoration, and Avian Populations in Midwestern Oak Forests

Periodic disturbance is an important determinant of the structure and composition of midwestern oak forests. Closed canopy forests develop without disturbance. Areas subject to disturbance by low intensity fires, however, tend to maintain relatively open canopy conditions and are known as either savannas (very open) or woodlands (moderately open). Fire suppression in the twentieth century has caused the widespread development of closed-canopy forests and encroachment by mesophytic, often non-native, plant species. Accordingly, midwestern oak savannas are viewed as one of the more threatened habitats/ecosystems in North America and in need of restoration.

Animal communities have likely responded to these recent changes in forest habitat, but few data exist. No bird species are found only within savannas, but regional declines of many species associated with "open" habitats are worrisome. In 1994, a study was initiated to examine how periodic disturbance by fire and savanna restoration affect the community structure, reproductive success, and foraging ecology of birds in Illinois. Results from several treatment (i.e., burned) and control sites in central Illinois indicate that savanna restoration has significant effects on the structure of local bird communities. Species such as the Red-headed Woodpecker, Baltimore Oriole, and Eastern Wood-Pewee were more common in savannas, but others such as the Scarlet Tanager and Wood Thrush decreased significantly. Many of the species responding favorably utilize aerial foraging maneuvers that are typically associated with open habitats.

Data from over 800 nests indicated that, for several species, reproductive success was markedly greater in savanna or restored habitats than in closed-canopy forests. This result was a surprise because most data from Illinois reveal extremely low nesting success owing to habitat fragmentation and associated high rates of nest predation or parasitism.

Therefore, the effects of savanna restoration on birds are largely positive. The mechanism for enhanced nesting success in savannas or woodlands is unknown at this time; nor is it known if this result will be consistent in different ecological settings such as urban versus agricultural landscapes. An important question for future studies is the relationship (if any) between the size of a restored savanna and viability of constituent bird communities.

Jeffrey D. Brawn, Center for Wildlife Ecology

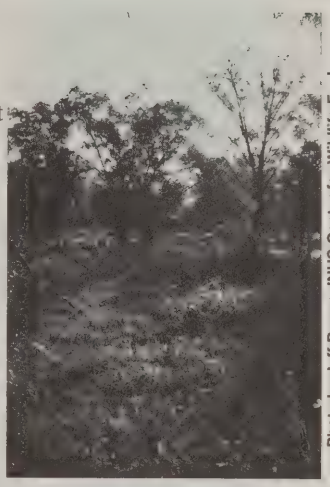


Photo by Jeff Brawn, INHS Center for Wildlife Ecology

A healthy, open savanna following a prescribed burn.

White Grub Management Options in Turfgrass

White grubs are major pests of home lawns and other turf areas. The larvae feed on the roots of grasses, causing large areas to turn brown and die from late August into November. Survey research has shown that there are two major species of white grubs in Illinois, the annual white grub or southern masked chafer, *Cyclocephala lurida*, and the Japanese beetle, *Popilla japonica*. Of lesser importance are the northern masked chafer, *Cyclocephala borealis*, and various species of true white grubs, *Phyllophaga*.

The adult beetles tunnel into damp soil beneath turf at night to lay their eggs. Work at the Survey has found that they prefer open sites, laying few eggs under tree canopies. Eggs are laid from late June in southern Illinois into late July in northern Illinois. With these weeks normally being hot and dry in Illinois, the egg-laying adults prefer watered lawns where the grass is green and the soil soft.

Their eggs hatch into C-shaped white larvae with brown heads and six legs. They feed on the roots of turf, causing dieback when their numbers are at least 8-10 per square foot. In the fall, soil temperatures dropping below 50 degrees F will cause them to migrate deeper into the soil for the winter. In the spring, they rise to the turf root zone, feed for a short time, and then pupate, emerging as adults in early summer.

Control of these insects has relied on relatively short-lived insecticides such as trichlorfon (Dylox), diazinon, and bendiocarb (Turcam, Intercept). These insecticides are applied in early August when grub numbers are high enough to cause damage. Before treatment,

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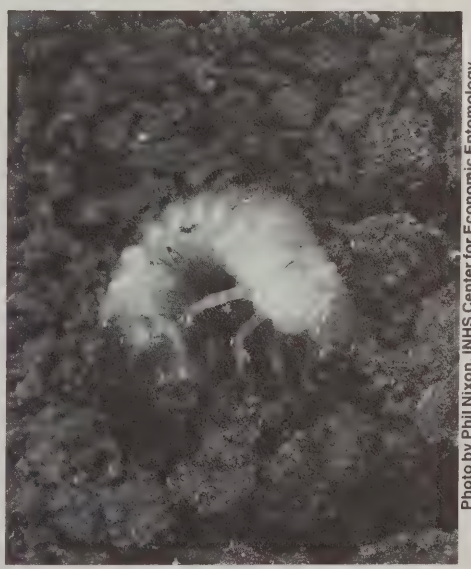

Photo by Phil Nixon, INHS Center for Economic Entomology

An annual white grub larva.

Species Spotlight

Downy Woodpecker

Susan Post

The Downy Woodpecker, *Dendrocopos pubescens*, was described by Audubon as "not surpassed by any of its tribe in hardiness, industry, or vivacity." The species inhabits most of wooded North America and is found in every Illinois county. Before European settlement this diminutive woodpecker preferred deep woods, but it readily adapted to the orchards and shade trees that replaced the forest.

Photo by Michael Jeffords, INHS Center for Economic Entomology

The Downy Woodpecker, Dendrocopos pubescens.

The Downy, with its contrasting black-and-white plumage, black-and-white head, and broad white stripe down its back, is Illinois' smallest woodpecker. Although it may be confused with the Hairy Woodpecker, the Hairy is half again as large as the Downy. The Downy's bill is also smaller and shorter.

Like all woodpeckers, the Downy has several features that adapt it to arboreal life. Its bill is straight and tapers to a sharp point and is an efficient tool for pecking and drilling into wood. Its nostrils are protected from flying wood chips by a covering of forward-directed tufts of feathers. The Downy has a slender, flexible tongue that is used to extract its favorite food, wood-boring insect larvae, from burrows. The skull's articulation with the bill has been modified to protect the brain, eyes, and ears from the effects of pounding on trees. A wedge-shaped tail consisting of twelve stiff and pointed feathers helps prop the bird while it climbs a tree or clings to a spot. Its toes, two directed forward and two directed backward, help the bird cling to the tree and ascend the trunk.

Male courtship activities begin during the warm days of March, and once a mate is chosen nest excavation begins. Downies nest in a cavity 8 to 50 feet above ground. The cavity, usually found in dead or dying wood, is gourd-shaped, turning downward and widening soon after penetrating the wood and extends to a depth of 8 to 12 inches. The entrance to the cavity is a perfect 1.25-inch circle, just large enough to admit the bird's body.

Egg laying begins during the end of March in the southern part of the state and extends to June 1 in the northern part of Illinois. Four to five pure white eggs are laid with both parents sharing in the incubation. The eggs will hatch in 12 days and by mid-June the young and adults are wandering about.

By autumn the Downy Woodpecker families have dispersed and each individual becomes solitary until the next breeding season. In autumn, when their tapping is heard they are busy excavating a roosting hole. The best time to watch these woodpeckers is in the winter when the trees and shrubs are bare of leaves. Also during the winter, Downy populations increase in urban areas. Each winter the industrious Downies earn another name, that of "suet gourmand." These attractive, active birds are thus a common site at most winter bird feeders across Illinois.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Illinois Woodpeckers

Objective: to learn about the woodpeckers that inhabit or visit Illinois

Materials: multiple copies of **Illinois Woodpeckers,** bird field guides

Vocabulary: boreal, extinct, migrate

Comments: Seven species of woodpeckers occur regularly in the state, two more are of rare or accidental occurrence, and one species is extinct. Woodpeckers belong to the bird family Picidae, which includes flickers and sapsuckers. The activity on the following page will acquaint you with the species of woodpeckers found in Illinois.

Procedure:

1. Students attempt to match the description in Column A with the common name in Column B. To help with the task, any field guide, such as the *Golden Guide to Birds of North America* or the *Peterson Field Guide*, should help.

2. Answers: 1= Common Flicker; 2= PileatedWoodpecker; 3= Red-bellied Woodpecker; 4= Red-headed Woodpecker; 5= Lewis' Woodpecker; 6= Yellow-bellied Sapsucker; 7= Hairy Woodpecker; 8= Downy Woodpecker; 9= Black-backed Woodpecker; 10= Ivory-billed Woodpecker.

Illinois Woodpeckers: Who Am I?

The Naturalist's Apprentice

Illinois Woodpeckers

Susan Post
and
Carolyn Nixon

Column A

1. I feed on the ground on ants. If I am a male or an immature I will have a black feather mustache. There are both red and yellow varieties of my species.

2. I am the largest woodpecker in Illinois. I drill rectangular holes, and if you are lucky enough to see me you are likely to say, "There goes Woody Woodpecker."

3. I am the only ladder-backed species of woodpecker found in Illinois. I have black and white horizontal stripes down my back. To contrast with the black-and-white coloring, I have a broad red stripe over the top of my head.

4. I have a bold color pattern—black, white, and red—but it's my red head that gives me away. I am a common winter resident and will be found in fairly good-sized flocks in the woods.

5. The best word to describe my color is smutty. I am a western species that on rare occasions may wander into Illinois.

6. I am a whiz at holes. I drill rows of small holes, both horizontal and vertical, in trees to form a nice pattern. I do not raise my young in Illinois, but instead migrate through during spring and fall.

7. I am black and white and have been called a larger version of the Downy.

8. I am the most common woodpecker in Illinois and also the smallest. My fondness for suet has earned me the nickname "suet gourmand."

9. I live in the boreal (northern) forests of North America (Canada), although on occasion I may be found in Illinois. Before I bore a hole in a tree, I must first strip all the bark off the area.

10. I was the largest woodpecker in North America, but now I occur no more. I am extinct. I fed on recently dead large trees and was at one time found in the swamps of southern Illinois.

Column B

Hairy Woodpecker

Red-headed Woodpecker

Red-bellied Woodpecker

Yellow-bellied Sapsucker

Pileated Woodpecker

Downy Woodpecker

Common Flicker

Black-backed Woodpecker

Ivory-billed Woodpecker

Lewis' Woodpecker

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White Grubs

continued from page 5

we recommend that grubs be scouted by cutting through the turf with a stout knife, pulling back the turf, counting the grubs in the root zone, and then returning the turf to its original position. Five or six samples should give you a good idea of the grub numbers present in an area.

Two newly developed insecticides, imidicloprid (Grubex, Merit) and halofenozide (Mach 2), last for several months once applied. This allows insecticide to be applied in the spring to obtain control in late summer. We strongly urge that these insecticides not be applied until the first half of July. At that time, one can tell whether grubs will be a problem and still allow at least three weeks for the insecticide to activate and become effective. If the adult grub flight is very small or the rainfall is high, such that unwatered turf is as green and lush as irrigated turf, Survey studies indicate that the chances of grub damage are very small and treatment is probably unnecessary. Mach 2 is available only to turf care professionals.

Two biological-type insecticides are being developed against grubs. Cruiser is the brand name for a nematode, *Heterorhabditis bacteriophora*, that is very effective against white grubs and should become available next spring to turf care professionals. M-Press contains *Bacillus thuringiensis japonica* toxins that are very effective against white grubs. It should become available in 1998 or 1999. Milky spore disease (Doom) containing the bacteria *Bacillus popillae* is effective against Japanese beetle but not annual white grubs. It has been difficult to obtain in recent years.

Any insecticide, chemical or biological, should be watered into the turf with at least one-half inch of water to get the material to where the white grubs are located. Remember, reduced or no irrigation during the summer allows the cool-season grasses, bluegrass and fescue, to go naturally dormant. Dormant turf will have reduced growth and be yellowish to brownish in color but will regrow in the fall as rainfall and cooler temperatures return. Unwatered turf is not attractive to white grubs and is very rarely attacked, eliminating the need for all of the above insecticide use. Only prolonged droughts, such as the one last experienced in 1988 in Illinois, are likely to kill the turf.

Philip L. Nixon, Center for Economic Entomology

Illinois Natural History Survey Reports is published bimonthly by the Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820. Headquartered on the campus of the University of Illinois at Urbana-Champaign, the Survey is a division of the Illinois Department of Natural Resources.

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ILLINOIS NATURAL HISTORY SURVEY

Reports

March/
April 1998
No. 350

INSIDE

One fox pup was consistently found in Memorial Stadium and scat was found several times on the bleachers...

Coyotes and Foxes in the Town and Country

Since the 1960s, coyote (*Canis latrans*) populations have increased and stabilized while red fox (*Vulpes vulpes*) populations apparently have decreased throughout Illinois. Previous studies suggest that coyotes are intolerant of foxes where their ranges overlap. Some farmers, trappers, and hunters who recall seeing higher numbers of foxes in the past now believe there are "too many" coyotes and blame coyote predation for decreasing fox numbers and low pheasant populations. Foxes may be more tolerant of human activity and thus persist in agricultural areas by exploiting habitat near human development.

We are trying to determine the nature of coyote intolerance towards foxes (direct aggression? competition for a limited resource? etc.). With funding from the Illinois Department of Natural Resources (IDNR) Furbearer Fund, researchers from the Illinois Natural History Survey and University of Illinois are using radiotelemetry to study dispersal, habitat use, and mortality of foxes and coyotes in urban and rural habitat that they share. Preliminary results suggest some emerging patterns of urban and rural fox pups. Nearly all the fox pups in developed areas have died prior to dispersal due to sarcoptic mange, while over half of the rural fox pups have died after being hit by cars. To date, no fox mortalities have been attributed to coyote depredation. Coyote pups also have had high mortality rates

Photo by Tim Van Deelen, INHS Center for Wildlife Ecology

Co-author Todd Gosselink with young coyote.

(80%), but most of the mortality occurred during dispersal and the causes were due mostly to car collisions and hunters. The mortality causes for adults were similar. Nearly half of the coyotes were shot over the winter months, while the majority of the adult foxes were hit by cars. Den locations of coyotes and foxes in the rural areas were located in contrasting habitats. Coyote dens were typically in the middle of a mile section, along drainage ditches or fence rows, while rural fox dens were all located under abandoned or little-used farm buildings.

Radiotelemetry continues to reveal interesting behaviors. Both species tend to prefer cornfields over soybean fields during hot summer days. On several occasions, foxes were found in the middle of subdivisions or small towns prowling people's yards at night. Foxes also use

Continued on back page

Western Corn Rootworm Flight Activity in Soybeans

Imagine you are a farmer standing in an east-central Illinois cornfield. It is July 1995, and for as long as you can recall, crop rotation has controlled the western corn rootworm (WCR) in your first-year corn (corn planted after another crop, usually soybeans) — that is, until now. Instead of row after row of erect green corn plants, you're facing a patchy field of wilting stalks leaning this way and that. You pull up a plant and find that the roots are being nibbled away by the maggotlike larvae of the WCR beetle. You are not alone, because the same story is playing out all over the region: first-year corn is devastated by a pest that should not be there.

Photo by Eli Levine, INHS Center for Economic Entomology

Corn lodging caused by larval rootworm feeding.

The WCR is one of the most serious insect pests of corn in the Midwest. Adult WCR beetles, active from July through frost, have one generation per year. Adults feed on corn pollen, silks, kernels, and foliage. Eggs are laid in cornfields from July to September; normally, few eggs are laid in other crops. Eggs remain in the soil until spring and they hatch in late May and early June. The larvae can survive only on the roots of corn and a few grasses. Root feeding reduces the water and nutrient supply to developing plants. Extensive injury makes plants susceptible to lodging (plants lean over or elbow and are difficult to harvest) and may lead to root and stalk rot infections, resulting in further damage.

Until recently, crop rotation, a method of planting corn and soybeans (or another crop whose roots don't support WCR larval development) in alternate years, controlled the WCR. Rotation disrupts the WCR life cycle because soybeans are grown where corn was planted the previous year. Since WCR lay eggs almost exclusively in cornfields and the larvae need corn roots to develop, planting soybeans where WCR eggs were laid starves the young larvae. Rotation allows first-year corn to be produced without WCR-targeted soil insecticide treatments. Indeed, crop rotation has been one of the great "success stories" for controlling the WCR.

Unfortunately, a behavioral change in some WCR populations is threatening crop rotation. Beginning in 1993, serious WCR larval injury to first-year corn in east-central Illinois and northwest Indiana began to increase. Growers who had successfully controlled WCR with crop rotation in the past suffered serious crop losses. In the early Illinois outbreaks of 1987-1992, it was suspected that pyrethroid insecticides used in seed corn had forced adult WCR beetles into nearby soybeans at egg-laying time; however, by 1993-1995, the problem region included commercial cornfields that were far from any pyrethroid-treated areas.

Studies ruled out pyrethroid repellency or a multiyear egg diapause as explanations, leaving the possibility that rotation itself had selected for a WCR strain that circumvented control by laying eggs in soybean fields (where larvae will emerge into corn the following spring and survive). Egg sampling and field collection of larvae confirm that WCR in east-central Illinois now lay eggs in both corn *and* soybean fields.

Since the initial damage reports, WCR injury to first-year corn following soybeans has increased in east-central Illinois and northwestern Indiana. Unlike 1995, favorable weather during the summer of 1996 enabled corn plants to tolerate WCR larval root damage; few damage reports were received. During 1996, our monitoring revealed that beetles were moving out of corn and into

Continued on next page

Rootworms

continued from previous page

soybean fields (and other crops) soon after their first detection in corn; thereafter, WCR populations remained higher in soybeans than in corn.

During the 1996 growing season, we were amazed to see that WCR from our problem area were feeding on soybean foliage in the vicinity of nutritionally suitable corn plant parts. Curiously, laboratory studies demonstrated that the soybean plant is a poor food for adult WCR. WCR that were fed only soybean plants (for two weeks) produced no eggs, weighed less, and died before their siblings, which were fed an artificial diet or one of corn silks, tassels, foliage, and immature ears. We also noted that beetles restricted to a soybean diet were much more active than WCR that were fed better diets. Increased activity is a frequent insect response to impending starvation; by moving more actively, the chance of finding food is improved. The lost vigor of soybean-feeding insects was restored by feeding on corn plant parts. Perhaps moving to corn after feeding on soybeans is a consequence of a malaise associated with the inadequate soybean foliage diet. Stomach content analysis of field-collected WCR revealed that 15% of females in cornfields had fed on both corn and soybeans within the last hour. Because WCR that are eating soybean foliage in the field carry significantly fewer eggs than those not eating soybeans, we believe WCR likely eat soybeans only after egg-laying. Given the selective advantage of laying eggs outside of corn, the cost of feeding on an inadequate food source, like soybeans, following egg-laying is small.

WCR egg-laying in soybeans is a problem of movement; crop rotation selects for individuals that move outside of corn to lay eggs. Using a variety of trapping and monitoring methods, we've made exploration of WCR movement a major focus. We have found a variable pattern of WCR movement in the field. Days with high WCR movement frequently were those with moderate to low wind and warm temperatures, while those with less movement had higher average wind speeds. Beetle abundance also changes in periodic fashion during the day; WCR abundance peaks in early to mid-morning samples and just prior to sunset. Significantly fewer WCR are present in the soybean field during late morning and afternoon. Direct observation of insect immigration to and emigration from soybean fields corroborate sweep-sample abundance data.

Photo by Joseph Spencer, INHS Center for Economic Entomology

Entomologist Joe Spencer taking aerial sample of corn rootworms.

Our behavioral data reveal a population of insects that may be found in a number of different crops and weeds at times during the growing season when corn is nutritionally at its best. Perhaps close proximity to corn and a capacity to recover from poor food choices by eating corn is behind the WCR willingness to consume a plant (like soybeans) whose tissues do not support adult maintenance or reproductive development.

Egg-laying by WCR beetles in soybean fields continues to be a serious threat to the continued efficacy of a corn-soybean crop rotation for rootworm management. Because crop rotation rewards female WCR who deposit all or some of their eggs outside of cornfields, evolution of the new behavior by the WCR can hardly be unexpected.

We gratefully acknowledge funding from the Illinois Council on Food and Agricultural Research (C-FAR) and the Illinois Soybean Program Operating Board (ISPOB) that supported this research.

Joseph L. Spencer and Eli Levine, Center for Economic Entomology; Scott A. Isard, Department of Geography, University of Illinois

Photo by Joseph Spencer, INHS Center for Economic Entomology

Western corn rootworm female on corn leaf.

Anuran Call Surveys

Photo by Michael Jeffords, INHS Center for Economic Entomology

The green tree frog, Hyla cinerea, *found in extreme southern Illinois.*

Over the last few years there has been increased concern about worldwide population declines and even extinctions of frog and toad species. Habitat destruction and degradation are clearly responsible in some cases, but the most alarming declines have occurred in relatively pristine environments, such as the rainforests of eastern Australia and the cloud forests of Costa Rica. Because these declines cannot be attributed to the direct impact of human activities, scientists have become concerned that one or more global factors, such as increased ultraviolet (UV) radiation or acid rain, might be adversely affecting all amphibians.

This problem was considered important enough that, in 1991, the Declining Amphibian Population Task Force (DAPTF) was formed. One of the first research priorities identified by the task force was to investigate whether the reported declines might actually be normal population fluctuations experienced by healthy amphibian populations. To distinguish between real global decline and normal fluctuation requires baseline population data for as many species as possible over several years. In 1996, protocols for long-term monitoring of amphibian populations were proposed by a group of scientists assembled by the Biological Resources Division (formerly the National Biological Survey) of the U.S. Geological Survey. These protocols, which included terrestrial salamander monitoring, anuran (frog and toad) calling surveys, aquatic surveys, western surveys, and amphibian atlassing, were designed to be carried out by volunteers using limited outside resources. Among these, anuran call surveys were field checked first because they had the fewest "bugs" to be worked out and were the most volunteer-friendly.

The anuran call survey protocol requires that each participant drive an assigned route in daylight, before the start of frog and toad breeding season, and locate 10 "stops." Each stop must be a wetland or potential amphibian breeding habitat, a minimum of 500 meters (0.3 miles) from each other, and a maximum of 200 meters (0.12 miles) from the road. Once 10 stops are established, the volunteer drives the route at night and records frog calls for a specific amount of time at each stop. The data collected for each route would be analyzed every five years to document amphibian population fluctuation.

The protocol stressed that randomly chosen routes are vital to statistical rigor of the program. However, I was concerned that some of the randomly chosen routes would fail to include a sufficient quantity of potential amphibian breeding habitat in some highly agricultural areas of the state. This is a problem because "failed routes" will not keep the interest of the volunteer and participation will drop rapidly. In addition, routes without enough stops do not add any information toward the goal of the survey: to establish baseline amphibian population levels. I decided to enlist the help of Illinois Department of Natural Resources Natural Heritage biologists and evaluate the randomly chosen routes in Illinois to see if these concerns were real.

In our study, 14 different field personnel evaluated 75 call routes. The recording of stops was standardized as much as possible by choosing the type of habitat at a stop from a list of wetland types. This procedure was followed until 10 stops were recorded or 30 km (20 miles) had been traveled for each route.

Eight of the 75 routes failed: 2 routes did not have any potential amphibian habitat because they went through big cities, 2 routes had to be terminated before 10 stops were reached because of road conditions, and 4 routes did not have 10 qualifying stops within our predetermined reasonable driving distance (30 km) because of agricultural practices. This level of success, 89%, is higher than we expected based on our experience with amphibian breeding habitat throughout most of Illinois. It provides the motivation we need to take the anuran call surveys in Illinois to the next level: gauging volunteer interest. If anuran call surveys sounds like something you would consider undertaking, send a letter to:

Chris Phillips
Illinois Natural History Survey
Center For Biodiversity
607 E. Peabody Drive
Champaign, IL 61820

Christopher Phillips, Center for Biodiversity

Effects of Diversity on Ecosystems

Biodiversity has become an increasingly important issue in ecology and for the general public. The loss of diversity raises philosophical and ethical questions ranging from our responsibility as stewards to the intrinsic value of nature. While highly discussed, little is known about the role diversity plays in creating and maintaining ecosystem structure nor about its role in ecosystem functions (e.g., nutrient cycling, systemwide productivity).

Historically, biodiversity questions have centered on how environmental characteristics (e.g., latitude, precipitation, and productivity) drive patterns of species richness. In recent studies, however, the questions have been expanded to how diversity affects the performance of an ecosystem, if at all. Using terrestrial systems, researchers have demonstrated that varying diversity levels can have variable effects on the ecosystem. Results indicate changes to resistance and resilience to disturbance, productivity, and nutrient dynamics as responses to changes in diversity. Other studies, while maintaining the value of diversity, question the degree of influence diversity has on ecosystem functions. However, to our knowledge, none of these studies have examined these questions in an aquatic setting.

The purpose of our study is to examine the relationship between fish species diversity and aquatic ecosystem structure and function. Using three levels of fish species diversity (2, 6, and 9 species) in pond enclosures, we were able to obtain preliminary results that support the hypothesis that diversity affects the ecosystem in some way. We found higher zooplankton (microscopic crustaceans) densities and higher chlorophyll concentrations in treatments with higher fish diversity. A diversity index (a numerical indicator of diversity levels) for the zooplankton assemblage indicates that increased fish diversity increases zooplankton diversity. Water column nutrient levels also appear to increase with increased fish diversity.

Photo by Sean Callahan, INHS Center for Aquatic Ecology

Researcher Frank Bradley inspects enclosures where pond experiments are conducted.

These results, while preliminary, suggest an effect of diversity on ecosystem structure and function in aquatic systems. Diversity is an important topic, with laws having been enacted in attempts to stem the loss of species, all without a fundamental understanding of the role of diversity. We hope that future analysis of our work will provide us with a better understanding of the environment and the importance of diversity.

Sean Callahan and David H. Wahl, Center for Aquatic Ecology

Lyme Disease Alert

During spring 1997, INHS entomologist John Bouseman and Survey affiliate Dr. Jeffrey Nelson found blacklegged ticks, *Ixodes scapularis*, in Carroll, Grundy, and Will counties in northern Illinois that were infected with the causative agent of Lyme disease. Although the researchers had been aware of blacklegged tick populations in Carroll County since 1990 and in Grundy and Will counties since 1991, and had been monitoring the populations over the intervening years for the Lyme disease spirochete, the 1997 investigations provided the first positive evidence of the Lyme disease agent in ticks in those counties. This evidence resulted from the successful laboratory culturing of the spirochete. Prior to those discoveries, blacklegged ticks positive for the Lyme disease agent were known in Illinois only from Ogle and Rock Island counties. In addition to finding infected ticks, the researchers noted larger populations of the ticks in the three counties.

The increase in tick numbers and the spread in the known range of infected ticks, especially on the threshold of the Greater Chicago Metropolitan Area in the case of Grundy and Will counties, is a matter of concern.

Illinoisans engaged in outdoor work and recreation are reminded to take precautions against tick bites. Anyone wishing to submit ticks for identification should send them in alcohol to John Bouseman at the address below.

John K. Bouseman
Illinois Natural History Survey
607 E. Peabody Drive
Champaign, IL 61820

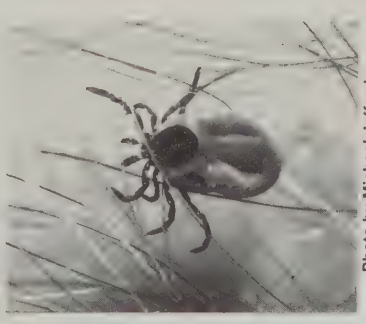


Photo by Michael Jeffords, INHS Center for Economic Entomology

The blacklegged tick, Ixodes scapularis, *on a human host.*

John K. Bouseman, Center for Economic Entomology, and Jeffrey A. Nelson, M.D., Rush Presbyterian St. Luke's Medical Center, Chicago

Species Spotlight

Bird's-eye Primrose

Susan Post

The bird's-eye primrose, *Primula mistassinica*, is a northern wildflower found on the tundra of Alaska, in the chilly regions of Canada, around the cold Great Lakes, and on the sheer dolomite cliffs above the Apple River in the Driftless Area of Illinois. When Dr. Herman Pepoon first found this plant over 90 years ago in Apple River Canyon in northwestern Illinois, he excitedly reported that the bird's-eye primrose was "tinting the bare rock a lavender purple with its multitudes of blossoms." Pepoon's peers reacted with much skepticism because they believed the bird's-eye primrose was a plant of boreal regions and that Illinois was too far south for it to grow. He countered the criticism with an invitation for all to come with him the next April on a primrose walk to prove his statement true. His peers came. They drove as far as they could into the canyons and walked the rest of the way to where the cliffs rose above the river. There for all to see with telescopes and binoculars was the bird's-eye or Canadian primrose—proof positive that it did indeed grow in Illinois!

Photo by Michael Jeffords, INHS Center for Economic Entomology

The bird's-eye primrose, Primula mistassinica.

Bird's-eye primrose is a diminutive plant. Its flower, with five heart-shaped, lavender-pink blossoms that encircle a round yellow dot called the bird's eye, is less than the diameter of a penny. Several blooms may form a cluster at the tip of a slender stalk that rises only 2-5 inches above a small rosette of pale-green notched leaves. Instead of growing upward toward the sun, this plant shoots out from the cliff at right angles. By the end of April, the plant is in full bloom, and by summer the seeds are ripe. The light seeds fall from the plant, mostly into the Apple River, but a few are deposited near the parent plant. Each plant is able to survive in less than a teaspoon of soil in the cranny of a rock, exposed to winds, sun, cold, and storms.

Botanists speculate that these northern denizens were carried south with the advance of the Canadian ice sheets. Plants that normally perished beneath the weight and scouring power of the glacier survived if their seeds were transported southward, on wind or ice, and deposited in a similar haunt. The glaciers missed the Apple River Canyon area and here the tiny seeds of the primrose lodged into the crannies of the dolomite cliffs. These cliffs, with a north and east exposure, are massive, thick-bedded, and towering. The dripping water, cool, clear, and saturated with lime, keeps the roots constantly cool in summer. In winter, the water keeps the immediate surface rock layers above freezing, ultimately forming ice cascades that cover the cliff face and protect the root and crown buried beneath.

Although sights of the primrose "tinting the rock purple" are no longer possible, Pepoon's botanical pilgrimage may still be duplicated today. Just follow the Primrose Trail at Apple River Canyon State Park and cross the creek for a close-up view of this true glacial relict.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Living on the Edge

Objective: to understand that Illinois is a melting pot of plants and animals from regions north, south, east, and west of the state.

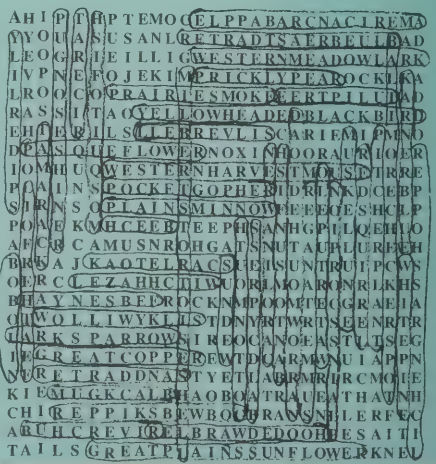
Materials: multiple copies of "**Living on the Edge**."

Vocabulary: melting pot, range

Comments: Illinois can thank its central location in North America for its great diversity of plants and animals. It is a melting pot for organisms from the north, south, east, and west.

Procedure:
On the following page are lists of plants and animals that make Illinois the edge of their ranges. See how many of them you can find in the Word Search. Hint: Plants and animals that are found predominantly north of Illinois will read from top to bottom, those from the south will read up from the bottom. Plants and animals that live primarily east of Illinois will read from right to left, and those that are primarily from the west will read left to right.

Answers:



NORTHERN

TAMARACK
RED SQUIRREL
WHITE PINE
MUSKELLUNGE
PUGNOSE SHINER
PITCHER PLANT
SUNDEW
BALTIMORE CHECKERSPOT
BOBOLINK
KARNER BLUE
MILBERT'S TORTOISESHELL

EASTERN

SILVERBELL
(AMERICAN) BEECH
RIVER CHUB
(EASTERN) SAND DARTER
BLUEBREAST DARTER
TULIPTREE
BLACK GUM
COBWEB SKIPPER
SCARLET OAK
WITCH HAZEL
SILKY WILLOW
AMERICAN CRABAPPLE
STAGHORN SUMAC
HOODED WARBLER

SOUTHERN

COTTONMOUTH
(AMERICAN) FEATHERFOIL
WATER TUPELO
RICE RAT
SPIDER LILY
NARROW MOUTHED TOAD
BALD CYPRESS
MOSQUITOFISH
SUMMER TANAGER
PLAINS SCORPION
LICHEN GRASSHOPPER
CAROLINA WREN
BANTOM SUNFISH

WESTERN

PASQUEFLOWER
YELLOWHEADED BLACKBIRD
PLAINS MINNOW
PRAIRIE SMOKE
PRICKLY PEAR (CACTUS)
WESTERN HARVEST MOUSE
PLAINS POCKET GOPHER
WESTERN MEADOWLARK
GREAT PLAINS SUNFLOWER
HAYNE'S BEE
GREAT COPPER
LARK SPARROW

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T A I L S G R E A T P L A I N S S U N F L O W E R K N E L

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Champaign, Illinois
61820 USA

Coyotes and Foxes

continued from front page

industrial areas and large city parks in the Champaign area. One fox pup was consistently found in Memorial Stadium and scat was found several times on the bleachers (possibly a comment on the 1997 Illini football season). Fox pups in the country consistently used culverts under country roads once they had left the dens.

Monitoring the dispersal relied heavily on aerial tracking since dispersal movement often included concentrated bursts of movement to new areas. One female juvenile coyote dispersed 60 miles southwest of Champaign before establishing a new range. Other coyotes are continually on the move and apparently do not maintain a discrete home range. The foxes are also extraordinary dispensers. One fox has been recorded moving 35 miles in six days or less, while another juvenile fox dispersed 50 miles north of Champaign before being trapped.

INHS researcher Rebecca Crawford examines captured red fox.

The adult foxes in the rural areas typically seemed to forage along roadsides during the night, while the coyotes often avoided roads and used drainage ditches and fence rows instead. On several occasions we located coyotes and foxes on or near farmsteads. The home range analysis has shown coyote and fox home ranges overlapping, and active fox dens often lie within the coyote home ranges.

As of January 1998 we have seen no evidence of coyote aggression toward foxes. Both species continue to use similar habitat and probably hunt for similar prey. Their interactions are obviously complex, and we find that conservationists are eager to learn more about this. This research will help IDNR managers design programs that will benefit both of these charismatic species.

Todd E. Gosselink, Department of Natural Resources and Environmental Sciences, University of Illinois, and Tim Van Deelen, Center for Wildlife Ecology

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ILLINOIS NATURAL HISTORY SURVEY

Reports

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

May/
June 1998
No. 351

INSIDE

Don't Blame It All on the Raccoons

Much of the natural habitat of the midwestern U.S. has been converted to agricultural use. In east-central Illinois, for example, row-crop agriculture covers about 75% of the land area and dominates the landscape. The remaining natural areas are also typically highly fragmented, creating large amounts of edge habitat. Recent conservation literature has focused primarily on the negative aspects of such habitat fragmentation, but some species thrive in these heterogeneous areas. In fact, medium-sized mammalian predators, such as coyotes, raccoons, and opossums, have increased to what are probably historic high densities in Illinois in the past few decades despite extensive conversion of natural habitats to agriculture. These species tend to be very opportunistic in their choice of food and habitat, as long as certain basic requirements, such as suitable den sites, are met. Some recent studies have shown that raccoons reach their highest numbers in landscapes with extensive agricultural edges, in wooded remnants in areas with extensive corn cover, and in fragmented landscapes with a high diversity of cover types, especially where there is proximity to water.

The good news for some kinds of animals can be bad news for others, though. Predators may use habitat edges as travel lanes or forage more intensely there, elevating rates of predation on songbird nests. In some areas of the Midwest where habitat fragmentation is extensive, rates of predation and nest parasitism by cowbirds can be so high that nesting songbirds do not fledge enough young to maintain stable populations. These areas may be population sinks for songbirds, meaning that populations must be maintained by constant immigration. Many kinds of predators take songbird nests, but at least two studies in the Midwest have implicated the raccoon as the major predator in agricultural regions. So far, though, few data show how different types of predators use habitat edges.

Photo by Steve Bailey, INHS Office of the Chief

A fox snake, one of several predators of songbirds.

At the Middle Fork Fish and Wildlife Area in Vermilion County, we radio tracked 15 raccoons and 4 opossums to determine whether they used habitat edges preferentially. We also conducted experiments using wicker nests baited with commercial quail and Zebra Finch eggs to determine if rates of predation differed in fields of different sizes (are predation rates lower in large fields?) or at different distances from habitat edges (are predation rates higher closer to the edge than out in the middle of the field?). This research is part of a Federal Aid in Fish and Wildlife Restoration project, funded through the Illinois Department of Natural Resources, being conducted by Scott Robinson, Jeff Brawn, Ed Heske, and other INHS biologists to study factors affecting nest predation on edge-, shrubland-, and grassland-nesting songbirds.

We tracked radio-collared raccoons and opossums at night from two vehicles with antennae mounted on the roofs. Coordinating our positions and timing by CB radio, we recorded simultaneous bearings for each animal several times per night between about 9 p.m. and 4 a.m. during three-week tracking sessions in June and August 1997. Using a

Continued on back page

...two studies in the Midwest have implicated the raccoon as the major predator in agricultural regions.

Long-term Dormancy in Freshwater Zooplankton

Zooplankton (microscopic organisms suspended in water) are an important component of a diverse array of aquatic systems. Although zooplankton differ in form and function, one trait common to a variety of species is the ability to produce two types of eggs. During favorable conditions, females produce subitaneous eggs, which develop immediately. When environmental conditions begin to decline for any number of reasons, females can switch to producing diapausing (resting) eggs, which enter a period of dormancy before resuming development. These diapausing eggs sink to the bottom of the lake, pond, or river until they receive the appropriate cues to resume development.

The cues vary among species and are not well understood, but likely include changes in light and temperature. Historically it was thought that these eggs served to carry the population through short-term environmental catastrophes, such as the winter or the dry season. However, recent studies have indicated that some diapausing eggs are capable of remaining viable in the mud for over a century. This longevity increases the life span of these organisms from weeks or months to years or even decades. In addition to being extremely long-lived, diapausing eggs can accumulate in densities ranging from 1,000 to 1 million eggs per m^2 of sediment. This storage of dormant stages forms an "egg bank" that is in many ways analogous to the seed banks of various terrestrial plant species. One consequence of storing dormant stages in either a terrestrial or aquatic system is that it creates a reservoir of both species and genetic diversity. This storage of biodiversity will affect the way in which a system responds to both natural and artificial changes.

In addition, the adults of many freshwater zooplankton cannot tolerate desiccation and therefore are not capable of actively dispersing overland from system to system. However, many of these specialized dormant stages resist drying, freezing, and gut passage through vertebrates, thus offering a series of passive dispersal options. Dormant propagules have been transported to new locations by ducks and other birds, wind and rain, raccoons, and insects. Humans have increased the rate of intercontinental dispersal when mud containing the diapausing eggs is introduced through ballast water exchanges or fish-stocking practices. These human-caused dispersal vectors are likely responsible for the introduction of at least two exotic zooplankters into Illinois waterways. The predacious *Bythotrephes cederstroemi*, which entered Lake Michigan in the mid-1980s, has been implicated in changes in the Lake Michigan food web. More recently, the suspension feeding *Daphnia lumholtzi* has been found in the Illinois River and several Illinois reservoirs.

Photo by Carla Cáceres, INHS Center for Aquatic Ecology

Adult Daphnia galeata mendotae *(left) and* Daphnia pulicaria, *both with subitaneous eggs. The* Daphnia pulicaria *is about 3mm long.*

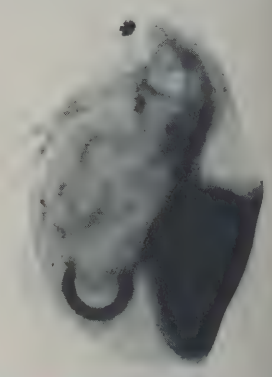


Photo by Carla Cáceres, INHS Center for Aquatic Ecology

Adult Daphnia pulicaria *with diapausing eggs. In* Daphnia *the female produces two diapausing eggs at a time, encased in a saddle-shaped protective covering known as an ephippium. When the female molts, the ephippium is released and sinks to the water bottom.*

The role of diapausing egg banks is rarely considered in aquatic ecology. This oversight is unfortunate because they are often an integral part of the system, and the response of systems to perturbations will be related directly to the ability of an egg bank to store diversity. Current research being carried out by the Center for Aquatic Ecology focuses on the causes and consequences of these eggs in aquatic systems. Understanding the role of dormancy is essential in making long-term predictions about ecosystem responses to anthropogenic disturbances. Long-lived dormant eggs can affect the ecology and evolution of the populations that produce them. Therefore, to fully understand the dynamics of the planktonic stage we must consider its ties to the dormant stage as well.

Carla E. Cáceres, Center for Aquatic Ecology

Wetland Bird Conservation in Northeastern Illinois

Half of the 42 bird species listed as endangered or threatened in Illinois nest exclusively in wetlands. This relatively high proportion of wetland species is largely due to the loss of much of the state's wetland habitat since the early 1800s. Continuing development, which threatens our remaining wetlands and promises further declines for wetland birds, is particularly acute in northeastern Illinois where, in spite of the loss of much of the presettlement wetland acreage, significant populations of wetland birds persist.

Photo by Michael Jeffords, INHS Center for Economic Entomology

A Great Egret, one of the colonial wetland-dependent birds in Illinois being studied by INHS scientists.

A major impediment for wetland bird conservation is the lack of information regarding the population dynamics and habitat requirements for these species. Here we outline three projects that aim to improve our knowledge of wetland-dependent bird species in northeastern Illinois.

I. Abundance and nesting productivity of wetland-dependent birds in northeastern Illinois.

Dr. C.R. Paine of the Max McGraw Wildlife Foundation, in cooperation with the Illinois Department of Natural Resources (IDNR) and the U.S. Fish and Wildlife Service, is conducting a long-term study of wetlands that is designed to provide accurate estimates of the regional abundance and distribution of wetland birds.

Study sites are systematically searched for nests and the fate of all nests recorded. Characteristics (physical and floral) of marshes and nest sites are also recorded. During the 1997 field season a team of 5 researchers working in 10 wetlands located and monitored 450 nests of 13 species. In the coming field season the effort will grow to 11 workers monitoring 90 wetlands.

The goals of this project are to:

1. develop estimates of the distribution and abundance of wetland-dependent birds on a regional scale,
2. assess the health of wetland bird populations in the region,
3. evaluate the effects of habitat characteristics on nest productivity, and
4. develop conservation priorities for wetland birds in the region.

II. The population dynamics of Yellow-headed Blackbirds in northeastern Illinois.

IDNR Natural Heritage biologists have recorded the presence and absence of Yellow-headed Blackbirds at marshes in northeastern Illinois over the past 20 years. These data indicate that Yellow-headed Blackbirds move among sites from year to year, making it difficult to predict the habitat requirements of the population in the long term. In order to better understand the movements of these birds INHS and IDNR scientists are color marking large numbers of individuals.

The goals of this study are to:

1. quantify the reproductive success of Yellow-headed Blackbirds,
2. assess habitat characteristics that favor Yellow-headed Blackbirds, and
3. assess site fidelity and dispersal in the area.

III. Use of foraging habitat by herons and egrets in northeastern Illinois.

One of the most difficult problems involving wetland bird conservation in rapidly developing areas is the protection of foraging areas required by colonial waterbirds (e.g., herons and egrets). These species nest in tight aggregations in small areas but forage up to 20 km away in the surrounding wetlands. In order to protect the foraging habitat of these species it is necessary to have accurate estimates of habitat utilization on a large scale. Gathering these data presents significant problems concerning both sampling design and logistics. To overcome the logistical problem volunteers will be used to gather foraging data throughout the region. This summer, trained volunteers from the Bird Conservation Network will collect preliminary data at 12 marshes in Lake and McHenry counties. Information gathered this year will be used to design a long-term monitoring program scheduled to begin in 1999.

Photo by Michael Jeffords, INHS Center for Economic Entomology

A typical wetland in northeastern Illinois that serves as habitat for many species of animals.

David Enstrom, Charles Paine, Mike Ward, and James Herkert, Center for Biodiversity

Illinois Earthworms: Indicators of Soil Health?

Photo by Ed Zaborski, INHS Center for Economic Entomology

A nightcrawler (Lumbricus terrestris) in its permanent vertical burrow.

Soil is one of Illinois' most valuable natural resources. It supports biomass production (including food, fiber, and energy); it filters, buffers, and transforms environmental pollutants; and it provides a biological habitat and genetic reserve for a vast number of organisms. The ability of soil to perform these functions is called soil quality or soil health. In recent years, concerns about the sustainability of food production and the off-site impacts of soil degradation have given impetus to efforts to develop objective criteria for assessing and monitoring soil quality. Although the initial focus in developing soil quality criteria has been on chemical and physical properties, scientists recognize that many important functions of soil, such as decomposition and nutrient cycling, are mediated by the organisms living in soil, and that an objective, comprehensive assessment of soil quality should include biological parameters. The soil is home to a complex community of organisms that includes bacteria, fungi, protozoa, nematodes, potworms, earthworms, mites, springtails, millipedes, centipedes, and other arthropods, so there are many potential candidates for biological indicators of soil quality.

Earthworms are the largest and most familiar soil invertebrates in Illinois soils. They are important members of the soil community because they can be the most abundant invertebrates by weight, reaching up to 1,000 lbs live weight per acre in some agricultural soils, and even more in unmanaged soils. Furthermore, because of the ability of earthworms to redistribute large amounts of soil and organic matter (roughly as much as their own body weight each day), they may shape the rest of the soil community and important ecosystem processes such as water infiltration, nutrient cycling, and decomposition. In Illinois, about 35 species of earthworms have been reported. Of these, roughly half are native species about which we know very little. The remainder are mostly European species that probably came to North America in soil used for ship ballast or on the roots of nursery stock.

Photo by Ed Zaborski, INHS Center for Economic Entomology

A nightcrawler out of its burrow and crawling on pavement.

During May-June 1997, as part of the Illinois Soil Quality Initiative (ISQI), Survey scientists sampled earthworm populations on 12 Illinois farms in conjunction with sampling of physical, chemical, and microbiological properties by University of Illinois soil scientists. Farms were clustered in groups of three that had similar hydrology and soil type but different management systems: 1) no-till corn-soybean rotation, 2) conventional tillage corn-soybean rotation, and 3) conventional tillage with a longer rotation including a perennial hay. We collected samples from cornfields on each farm (nine samples per field) as well as from uncultivated grassy border areas of each field (three samples per field). For each sample, we dug soil from a pit 12 inches x 16 inches x 8 inches deep. We hand sorted the earthworms from each sample, then counted, weighed, and (in the case of adults) preserved them for identification. We kept juvenile worms in lab culture for identification when they matured.

Because of our method of sampling, we collected mostly endogeic earthworms—worms that tunnel back and forth through the topsoil and feed on buried decaying organic matter and organic matter-rich soil. We did not collect anecic earthworms, such as the nightcrawler, *Lumbricus terrestris,* that form permanent vertical burrows 3-9 feet down into the soil and pull plant residues from the soil surface into their burrows to feed.

The most striking observation

Continued on next page

Earthworms

continued from previous page

was the difference in abundance of earthworms between cultivated fields and their uncultivated grassy borders. Across all farming systems we estimated an average of 148,000 worms per acre within the fields (up to 292,000 worms per acre in one field) and almost four times as many, an average of 589,000 worms per acre, in the grassy border areas. In one of the grassy border areas, we estimated an abundance of 1.54 million worms per acre. The difference between in-field and grassy border populations was even greater when we considered the living weight of the earthworms: an average of 78 pounds per acre within fields, with a maximum of 179 pounds per acre, and almost 30 times that weight—an average of 2,263 pounds per acre and a maximum of 5,909 pounds per acre—in the grassy borders. Thus, topsoil-dwelling earthworms were not only less abundant within fields than in borders but they were also smaller. In contrast to the difference between fields and grassy borders, we were unable to detect a difference in the number or weight of topsoil-dwelling earthworms among the fields with different management practices.

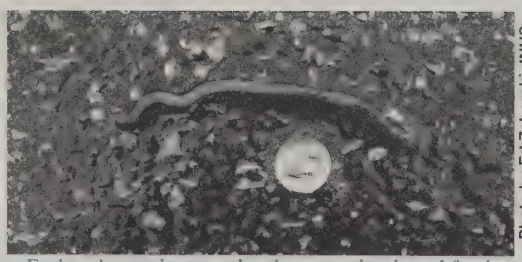
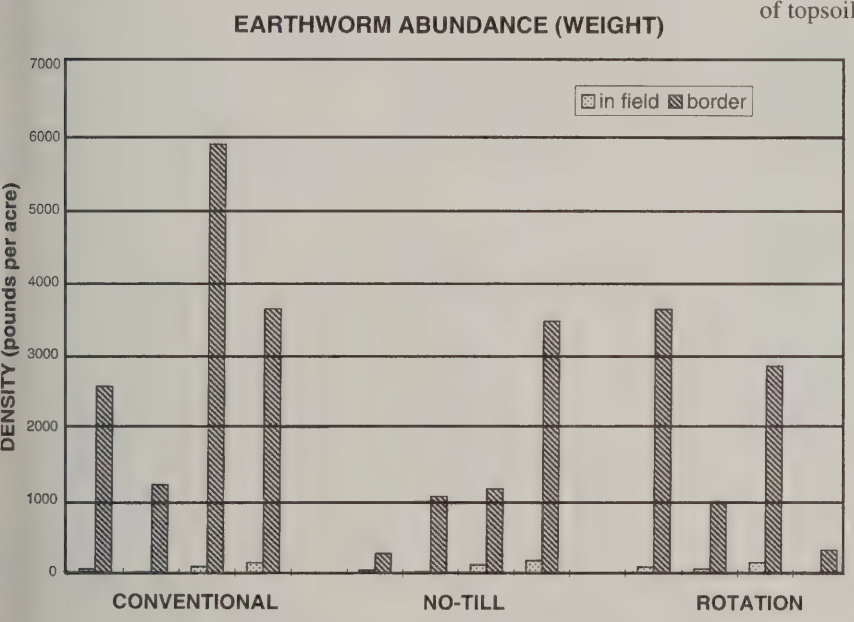
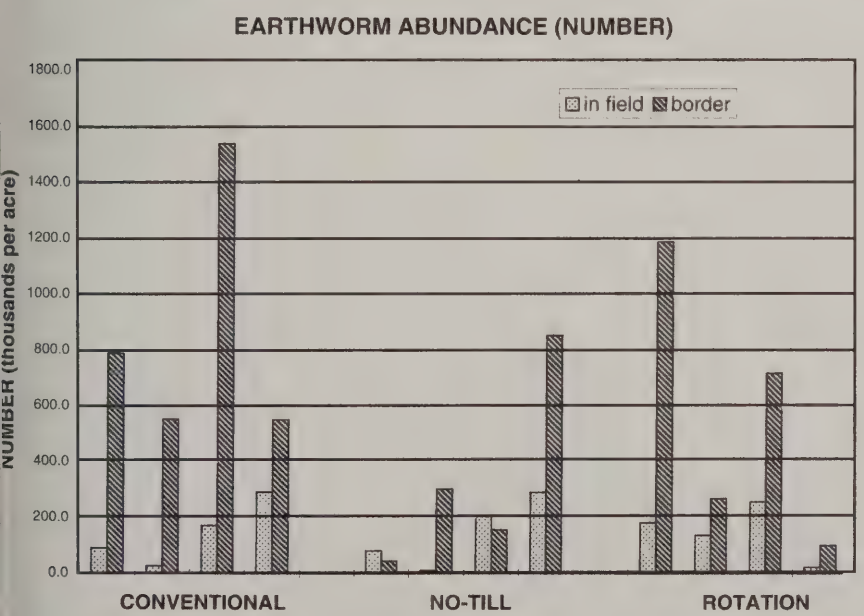


Photo by Ed Zaborski, INHS Center for Economic Entomology

Endogeic earthworm that burrows back and forth through topsoil and helps develop soil structure.





What caused the difference in earthworm populations between grassy borders and cropped fields? There are several possible explanations, keeping in mind that we sampled only topsoil-dwelling earthworm populations. During the winter, the thick layer of grass on the soil surface in the grassy borders may afford some protection to the soil; researchers have shown that bare soil freezes more deeply, resulting in higher earthworm mortality. The grassy borders may also provide a more abundant, stable, and nutritious food supply to support larger populations of earthworms. Agricultural practices and chemicals may result in higher mortality of earthworms within the field than occurs in uncultivated border areas. Finally, native earthworm species may not tolerate soil disturbance; we found them in the grassy border areas, but not within the fields.

We hope to relate our observations on earthworm populations to information about soil physical and chemical characteristics and soil management practices. By identifying factors that affect the abundance and structure of earthworm populations in agricultural soils, we hope to develop biological criteria for assessing and monitoring the health and quality of agricultural soils in Illinois.

Ed Zaborski, Center for Economic Entomology

Species Spotlight

Passenger Pigeon

Susan Post

"When one approaches the country of Illinois, one sees during the day, clouds of doves, a kind of wood or wild pigeon. A thing that may perhaps appear incredible is that the sun is obscured by them; these birds living only on the beechnuts and acorns in the forests, and are excellent in autumn; sometimes as many as 80 of them are killed with one shot."

N. Bossu while voyaging up the Mississippi, 1768.

The Passenger Pigeon, with its small head and neck, red sparkling eyes, long tail, and plumage that ranged from slatey blue on the head to grayish blue on the back, had an air of elegance. But appearances can be deceiving—these now-extinct birds, although beautiful, were powerful flight machines. The Passenger Pigeons' massive breast muscles were attached to a deep keel and their long, pointed wings allowed for speed as well as aerial acrobatics. Their dashing and wheeling, dipping and darting earned the bird the title of "blue meteor." Audubon wrote of the Passenger Pigeon, "When an individual is seen gliding through the woods and close to the observer, it passes like a thought, and on trying to see it again, the eye searches in vain; the bird is gone."

Photo from INHS image archives

A stuffed Passenger Pigeon on display at the Illinois Natural History Survey.

Passenger Pigeons were found only in eastern North America and were once the most abundant bird on earth, numbering billions. In Illinois, Passenger Pigeons were common summer residents in the north, especially along the Des Plaines River. Occasionally the birds would winter in southern Illinois.

Gregariousness was highly developed in these birds, so their activities —flying, roosting, resting, and nesting—were done in great numbers. When they landed on trees they formed "crowded rows," which caused branches to snap under their weight and their dung would "fall like hail." In Illinois residents were able to witness the great migrations of abundant Passenger Pigeons through the state, with great hordes flying overhead from late March to early April. A single flock could stretch for 300 miles—from Chicago to St. Louis—and take 14 hours to fly by.

The Passenger Pigeon had a varied diet. Staple foods during the fall, winter, and spring were acorns, chestnuts, and beechnuts; during the summer soft fruits were eagerly sought. Their affinity for nut-producing trees made Passenger Pigeons an important component of the eastern deciduous forest. Unlike chickens, these birds never obtained food by scratching with feet, instead they overturned leaves and soil with their bills. To gather nuts they would land on the outer ends of oak or beech limbs, seize the nut in their bill, fan backwards with their wings, pull the nut from the tree, and swallow it whole.

Like the periodical cicada of North America and the wildebeest of African plains, the Passenger Pigeon's strategy for survival was overwhelming abundance. Nesting aggregations were so vast that local predators (hawks, raccoons, foxes, and opossums) couldn't wipe them out. Humans, though, were a different story, and by the beginning of the 20th century only a few captive birds were left. Man had succeeded where other predators had failed.

The arrival of great flocks of Passenger Pigeons always meant food for settlers, but until the advent of market hunting (harvesting the birds for faraway markets), local people had very little impact on pigeon populations. By 1840, market hunting was a major industry. The coming of the railroads allowed rapid access to major nesting colonies and provided a quick way to ship barrels of pigeons to the big cities. The telegraph informed market hunters of nesting colony locations. Hunters would attack a colony with guns, nets, saws, and poles, intent on taking as many birds as possible. Although many adults were shot, the commotion also caused nests to be abandoned; delectable nestlings were also part of the bounty. In nearly every breeding colony it was possible to harvest all the young, and this decimation happened year after year. Although destruction of the forests and overhunting are often given as causes for the bird's demise, the fact that the reproductive success of the Passenger Pigeon was nearly nonexistent for many years ultimately led to its end.

On March 24, 1900, the last wild Passenger Pigeon was killed in Pike County, Ohio, leaving the species represented by only a few captive individuals in zoos. Martha, the last Passenger Pigeon, died on September 1, 1914, at the Cincinnati Zoo.

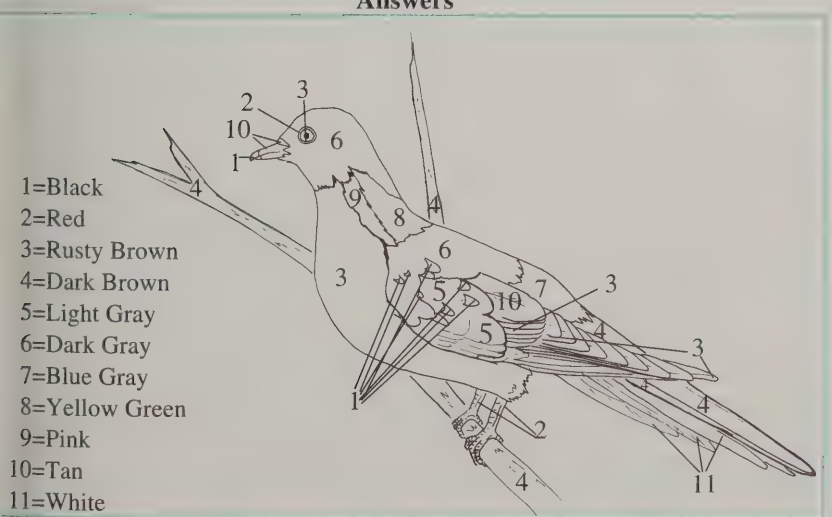
Aldo Leopold wrote of the Passenger Pigeon, "Yearly the feathered tempest roared up, down, and across the continent sucking up the laden fruits of forest and prairie, burning them in a traveling blast of life." Like a meteor that burns brightly across the sky for a few hours or days, the Passenger Pigeon experienced great success as a species before its light dimmed and died when Martha quietly slipped from her perch—its legacy only a handful of historical accounts and a few stuffed birds with vacant stares.

Teacher's Guide to "The Naturalist's Apprentice"

Color a Passenger Pigeon

You will never see a Passenger Pigeon flying through the sky. You will never see the subtle beauty of the rust-colored chest or the bluish gray back, or catch a glimpse of the iridescent greens and pinks as the sunlight strikes the feathers on its neck. Color the Passenger Pigeon below and try to imagine what a flock of thousands of them must have looked like!

Answers



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Raccoons

continued from front page

differential global positioning system (GPS) to pinpoint precisely the locations from which we took our bearings and a computer-based geographic information system (GIS) to map our data onto aerial photos, we could then plot the nightly movements and habitat use of our study animals at the Middle Fork. From these data, we could clearly show that raccoons and opossums used habitat edges extensively during their nightly activities, and were located less frequently than expected out in open fields away from edges. So, does that mean we can blame edge effects in nest predation on raccoons?

Our experiments with artificial nests showed there was a moderate tendency for predation rates on the quail eggs to be lower in larger fields, and a weak trend for predation rates to be higher near edges, as we expected. However, predation rates on Zebra Finch eggs showed no pattern. Further, only about 35% of the quail eggs we set out were depredated, whereas the total predation rate when the Zebra Finch eggs were included reached about 75%, close to the rate for natural nests at our study site. Because the quail and finch eggs were together in the same nest and we assume that a predator like a raccoon takes both eggs if it finds a nest, those cases where the finch egg was eaten but the quail egg was left indicate that some other predator was at work. For example, mice and chipmunks can prey on small eggs like finch eggs (and most songbird eggs), but can't break the larger, harder quail eggs.

A preliminary analysis of nest predation on over 1,800 natural songbird nests found at the Middle Fork by other biologists working on this project also did not show any clear spatial patterns relating to edges. Other aspects of our research are showing that natural areas embedded in this agricultural landscape attract and support high densities of a diversity of potential nest predators. Although some predators like raccoons may use edges extensively, some small mammals and snakes (which we are also radio tracking) may prey on nests far from edges. We hope to identify patterns of habitat use by different kinds of predators, and patterns of nest predation in different kinds of habitats and landscapes, that may point to management practices that could improve the nesting success of songbirds. In the meantime, don't blame it all on the raccoons.

Ed Heske, Dan Rosenblatt, and Julianne Newton, Center for Wildlife Ecology

ILLINOIS NATURAL HISTORY SURVEY

Reports

July/
August 1998
No. 352

INSIDE

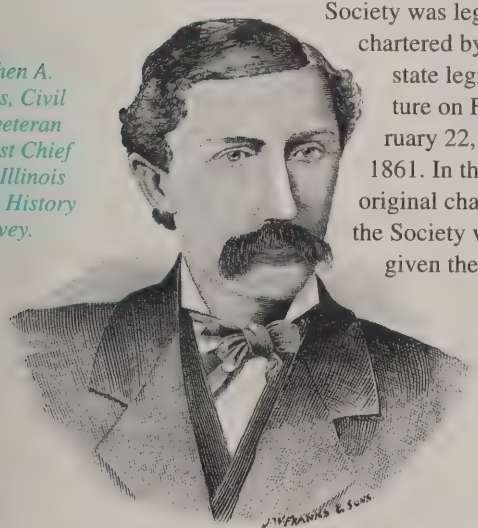
Illinois Natural History Survey is 140 Years Old

On June 30, 1998, the Illinois Natural History Survey became 140 years old. With a staff of 370 and an average of 120 scientific publications each year, the Survey is the largest and most successful of the state biological surveys in this country.

The foundation for what would become the Illinois Natural History Survey was laid by Cyrus Thomas, a lawyer, teacher, and self-taught entomologist from Jackson County. In a December 1857 meeting of the State Teachers' Association in Decatur, Thomas proposed that a Natural History Society of Illinois be formed. On June 30, 1858, the Natural History Society, parent organization of the Illinois Natural History Survey, was officially organized at Illinois State Normal University in Bloomington (now Illinois State University at Normal). The Natural History Society was legally chartered by the state legislature on February 22, 1861. In the original charter, the Society was given the dual purpose of preparing "a scientific survey of the State of Illinois in all the departments of natural history" and of establishing a museum of natural history at Illinois State Normal University.

Picture from INHS image archives

Original building of Illinois State Normal University at Normal where the Illinois Natural History Survey was founded and housed until 1884.



Picture from INHS image archives

Stephen A. Forbes, Civil War veteran and first Chief of the Illinois Natural History Survey.

In 1877, the General Assembly established a Natural History Museum at Springfield, and the Natural History Society Museum at Illinois State Normal University was renamed the State Laboratory of Natural History. The act that established the State Laboratory of Natural History enabled the institution to concentrate on research rather than on museum exhibits. Stephen A. Forbes, who had been appointed curator of the museum in 1872, was named director of the new State Laboratory of Natural History in 1877. In 1882, Forbes took on additional duties when he succeeded Cyrus Thomas as state entomologist.

In 1885, Forbes moved from Illinois State Normal University to the Illinois Industrial University at Urbana, which that same year was renamed the University of Illinois. With the approval of the state legislature, Forbes transferred the State Laboratory of Natural History and its staff, library, and research collections, which by that time were quite large, with him to Urbana.

In 1917, the research functions of the State Laboratory of Natural History and those of the Office of the State Entomologist were consolidated under the name Illinois Natural History Survey with Forbes as its first chief. The new Survey was incorporated into the Department

Continued on page 2

140 Years Old

continued from front page

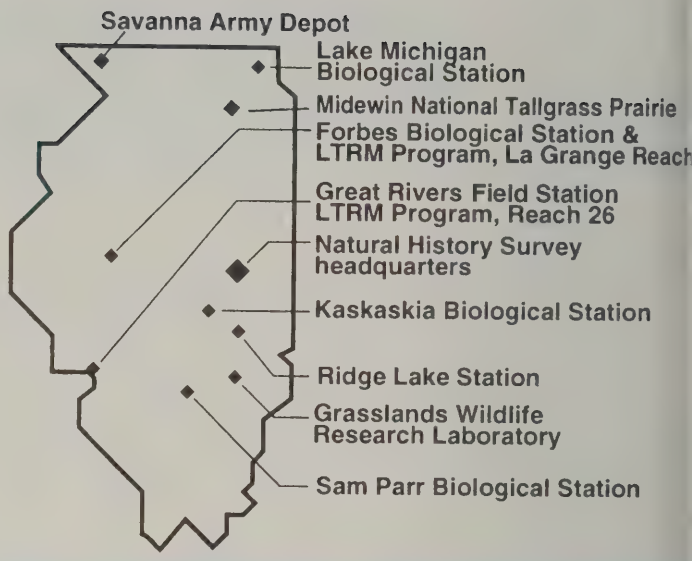
of Registration and Education with the other two state scientific surveys, the State Geological Survey and the State Water Survey. Also in 1917 the Board of Natural Resources and Conservation was created as the governing board of the scientific surveys.

In 1940 the Illinois Natural History Survey moved into laboratories and offices in the Natural Resources Building (NRB), its current location. In 1950 wings were added to the east and west ends of NRB which almost doubled the available space. Laboratories and offices at the Natural Resources Studies Annex (located south of campus at UIUC) were completed in 1972.

The first INHS field station was established by Stephen Forbes at Havana in 1894, and today it is known as the Forbes Biological Station. Other INHS biological stations include the Ridge Lake Station near Charleston, Sam Parr Biological Station in Kinmundy, Kaskaskia Biological Station at Sullivan, the Grasslands Wildlife Research Laboratory at Effingham, the Great Rivers Field Station in Alton, the Long-term Resources Monitoring Station (La Grange Reach) at Havana, and the Lake Michigan Biological Station at Zion. INHS has recently located field staff at two more research areas in the state—the Savanna Army Depot near Galena and the Midewin National Tallgrass Prairie in Will County.

Photo from INHS image archives

The Natural Resources Building complex at UIUC, site of current headquarters of the Illinois Natural History Survey.



Locations of research field stations of the Illinois Natural History Survey.

Stephen Forbes recognized the value of educating the public at every level about the contributions of the state's scientific agencies through publications and public relations activities. While he maintained close ties with the University of Illinois, he also recognized that Illinois was fortunate "to have a group of vigorous and imaginative 'statesmen' of science at the surveys, who played an important role in avoiding the narrow academicism of pure research and emphasizing the importance of public function of state-supported science." Maintaining a balance among our various roles to carry out a strong scientific research program, assisting in the education of students, and communicating the results of our studies to the public remain challenges for INHS to this day.

In 1978, the three scientific surveys in Champaign-Urbana and the Illinois State Museum in Springfield were transferred from the Department of Registration and Education to the newly created Institute of Natural Resources, which in 1981 was raised to departmental status and named the Department of Energy and Natural Resources. In 1996, the scientific surveys and the Illinois Waste Management and Research Center were transferred to the newly created Department of Natural Resources, and along with the Illinois State Museum, make up the state Office of Scientific Research and Analysis.

The Illinois State General Assembly in Springfield recently appropriated funds for INHS to begin Phase I planning and construction for a new research facility at UIUC.

Lawrence M. Page, Center for Biodiversity, and David L. Thomas, Chief, Illinois Natural History Survey

Grassland Habitats in Illinois

Tallgrass prairie once dominated much of the Illinois landscape, but these native prairies have been nearly extirpated. What grassland remains is fragmented within an agricultural and human-altered landscape. Additionally, non-native species have replaced native prairie species. Gone are the oceans of big and little bluestem, replaced by isolated fields and remnants. These grasslands currently constitute the habitats of species such as the endangered Henslow's Sparrow that are native to prairies. How native prairie species utilize the current landscape is not well understood.

We analyzed the distribution of grasslands throughout Illinois to better understand the current status of this habitat. Our goals were to identify existing large blocks of grassland, to identify areas with a high density of grasslands, and to characterize selected regions based on the size and abundance of grassland tracts. The derived distribution of grasslands was also compared with known locations of Henslow's Sparrows.

Analyzing the existing grasslands for all of Illinois' 56,000 square miles required the use of computer-based geographic information system technology. The land cover database of Illinois (INHS Reports, Nov./Dec. 1996) was used to create the initial map of grasslands. This database has a spatial cell resolution of 28.5x28.5 meters, requiring over 180 million such cells to cover all of Illinois. Approximately 17% of Illinois is classified as grassland, including roadways, railroad corridors, strip mine areas, old fields, pastures, and remnant prairies.

The current distribution of grasslands in Illinois forms an interconnected web of thin corridors, mirroring roadways, greenways, fields, and railway corridors. Our analysis began by isolating 12 contiguous tracts of grassland from thin connecting corridors and characterizing each tract by interior area and size. Tracts with 10 or more hectares (ha) of interior grassland were retained for analysis and classified as being larger than 10, 40, or 100 ha (Figure 1). All subsequent analyses were based on this representation of grasslands.

The amount of grassland within a county varies widely across the state. Will County has the greatest amount of grassland in tracts larger than 100 ha and also has the largest single tract (2,990 ha) (Figure 2). This tract lies within the Midewin Tallgrass Prairie. Another large, single tract (1,078 ha) occurs in Jo Daviess County at the site of the former Savanna Army Depot. Grasslands account for over 45% of the land cover of Jo Daviess county; however, only 1.1% of this is in tracts larger than 100 ha. Johnson County has the greatest number of grasslands larger than 100 ha but all are of moderate size (148-384 ha).

General locational data for 25 Henslow Sparrow sitings statewide were incorporated to evaluate our grassland model. This grassland bird species is listed as endangered in Illinois and is known to prefer large, idle tracts of grassland. Fourteen of the 25 Henslow Sparrow locations occurred in grasslands with interiors of at least 10 ha. Of these 14, 7 occurred in grasslands with interiors larger than 100 ha.

This is the first time the land cover database has been used for this type of analysis. Field studies will help validate the distribution of grasslands and the large tracts identified in our analysis. The results of this research, which was funded by the Heritage Division of the Illinois Department of Natural Resources, will help guide field work and restoration efforts by state biologists. The next step is to understand the ecological importance and functioning of these grassland areas as habitat for native prairie fauna in Illinois.

Mark Joselyn, Jocelyn Aycrigg, and Tony McKinney, Center for Wildlife Ecology; James Herkert, Division of Natural Heritage, Illinois Department of Natural Resources, Springfield.

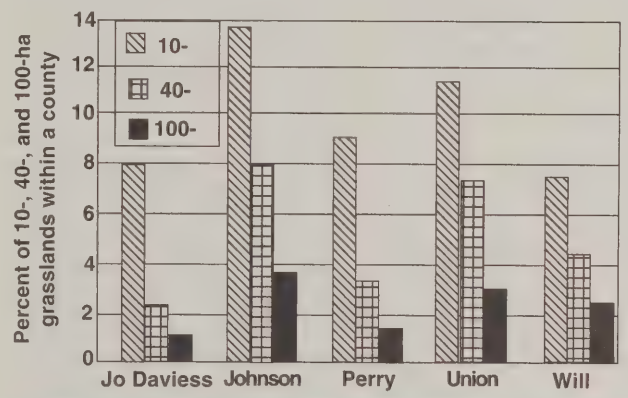


Figure 1. Percent of 10-, 40-, and 100-ha grasslands within five Illinois counties. In comparison to all counties, these five have the most 100-ha grassland tracts. The percent of total grasslands within each of these counties = 45.7% in Jo Daviess, 34.8% in Johnson, 26.2% in Perry, 27.7% in Union, and 22.2% in Will County.

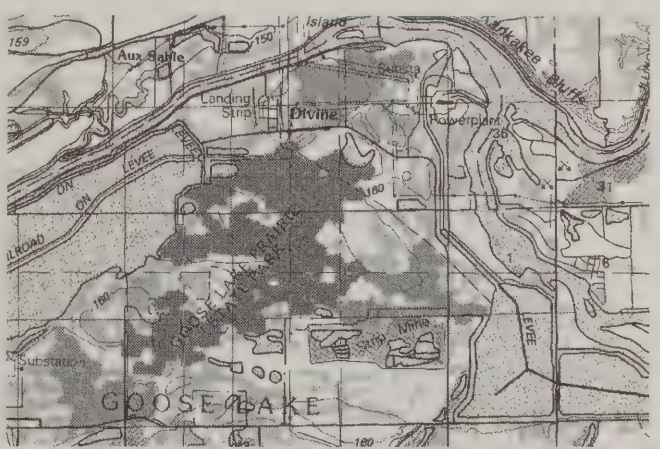


Figure 2. Grassland tracts near Goose Lake Prairie, IL, classified by size. Continuous gray indicates grassland; darker gray indicates larger tracts.

Ecological Numeracy

Ecological Numeracy is the ability to understand, interpret, and participate in the quantitative aspects of environmental debates and decision making. Acquiring ecological numeracy requires attentive thinking and dedicated practice, but not high-powered math. Skills that never go beyond one semester of calculus, and usually no more than advanced high school algebra, often allow one to slice through to the crux of a wide range of issues.

For several years, I have taught ecological numeracy to students of urban planning and natural resources and environmental sciences. Much of what we cover is summarized by four important equations, which I discuss below. I also provide an example of how we would use stock-flow thinking, related to equation 3, in the question of sequestering atmospheric CO_2 by growing trees.

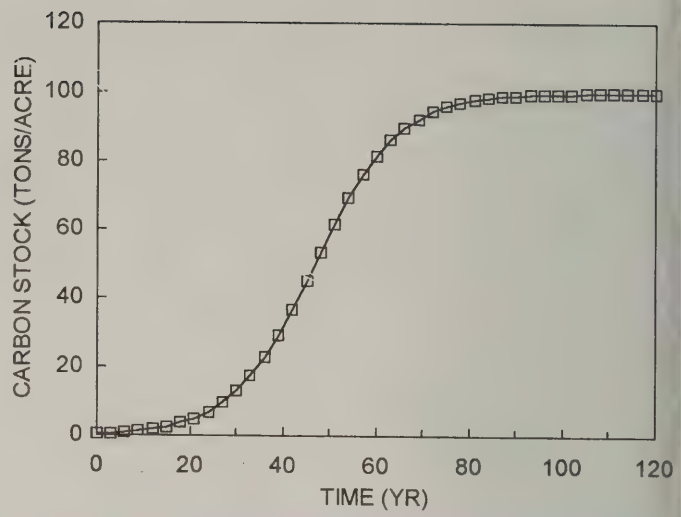


Figure 1. Approximate biomass storage (expressed as carbon) in a successional temperate forest.

Four Important Equations:

1. $I = PAT$

The impact (I) of an anthropogenic activity can be considered the compounding of population (P), per capita consumption (A), and technology (T). Useful for reality checks: Can T be made small enough so that a doubled human population consuming at 4 times today's rate will produce only one half as much pollution? Equation 1 tells us that T must be reduced to 1/16 of today's value, i.e., that pollution control must become 16 times better.

2. $1+x+x^2+x^3+...x^{n-1} = (1-x^n)/(1-x)$

The sum of a geometric series, used to stress the impacts of exponential growth and depletion of resources, discounting in cost-benefit analysis, and new schemes to modify Gross National Product to reflect sustainability.

3. $F_{in} - F_{out} = \Delta M/\Delta t$

The dynamic relationship between the change of a stock (M) and the flows in and out (F) during a time period Δt. Fundamental in understanding stocks and flows, pollution accumulation and dispersal, and population dynamics. Used in simulation modelling.

4. $\sum_{i=1}^{N} \epsilon_i X_{ij} + E_j = \epsilon_j X_j$

The most complicated expression (it describes simultaneous linear equations) is a variation of input-output economics. Used to calculate indirect effects such as "sunlight in an eagle," the labor required to make a car, bioaccumulation of pesticides in food chains, trophic positions in food webs, and the pollution from (on-site) "clean" electric heat. A recent application is an "ecological footprint" —the size of area impacted by a nation's lifestyle. All but two of the industrialized nations (Canada, Australia) have a footprint larger than their actual area.

An example of stock-flow thinking:

Often one reads that an afforestation project will sequester X tons of atmospheric carbon dioxide per acre per year, with no mention of how long it can do this. The logistic curve (Fig. 1) approximates the buildup of fixed carbon (in the soil as well as in tree biomass) as a forest succeeds on previously bare ground. The graph shows the stock (in tons of carbon/acre), while the graph's slope is the uptake rate (a flow, in tons/acre-yr). For this example, uptake rate is maximum at around 50 years. Eventually the forest matures, its biomass levels out, and its net uptake rate goes to zero. At that point this forest has zero net effect on atmospheric CO_2. To point to the value of X and not be explicit about its transient nature is irresponsible. A fruitful discussion requires that all participants agree where they are on the logistic curve.

Three possible responses to this "saturation" problem are promoted, and each can be interpreted in terms of Figure 1.

1. Current research is asking whether increased CO_2 concentrations will stimulate additional vegetation growth. In terms of Figure 1, we can ask if the eventual carbon storage (the asymptotic level) will increase, or just the rate of approach to it, that is, the slope.

2. To make a plot of ground useful in the long term for carbon storage, the trees could be cut and prevented from rotting or burning, and afforestation begun again. The average rate of carbon storage can be estimated from Figure 1, assuming a rotation time.

3. The trees could be burned in an application now using fossil fuel. A forest rotation for biomass fuel will have zero net long-term effect on atmospheric CO_2 itself, but it will reduce overall emissions by displacing the original fossil fuel combustion. Again, calculations based on Figure 1 allow estimating this displacement.

Robert A. Herendeen, Center for Aquatic Ecology

Improved Soybean Insect Research Database

The Soybean Insect Research Information Center (SIRIC) was established by the Illinois Natural History Survey and the University of Illinois' Agricultural Experiment Station in 1969 to comprehensively compile the world literature of arthropods associated with soybeans. The bibliographic database was computerized in 1972, making SIRIC one of the first agricultural databases to enter the electronic age. The database currently consists of over 44,000 references on soybean-related arthropods; over 10,000 of these deal with soybean entomology. The database, more than a simple collection of citations, has three important strengths:

1. The structure of the database has been designed by a library science professional. At its core is a controlled vocabulary, or thesaurus, of over 8,000 species names and subject terms, organized hierarchically. The thesaurus allows for more precise and powerful searching of the database than could be provided by simple keyword searching.

2. Entomologists have provided their expertise in the selection and organization of the subject terms chosen for the thesaurus. Entomologists have also read and assigned subject terms to the documents in the database, ensuring that the contents of the documents were accurately assessed.

3. The collection of documents on the subjects of interest to SIRIC is intended to be exhaustive.

The collection includes documents retrospectively into the 19th century, and special efforts have been made to identify documents outside of the mainstream publishing channels commonly termed "grey literature." As a result, SIRIC contains many documents that are not found in other agricultural sources. Thus, the SIRIC database is of higher content value than that of other commercially produced databases in agriculture.

SIRIC was closed in 1990, but with funding for 1997 and 1998 from the Illinois Soybean Program Operating Board, the database is now being updated. This revitalization project will make a valuable resource on the world literature of arthropods associated with soybeans available to a wide range of potential users, including producers, agribusiness, and researchers. With the rapid development of the Internet and the World Wide Web, it is now both appropriate and feasible to make this database available through this new medium to those who have an interest in soybeans and their

continued on last page

Photo by Michael Irwin, INHS Center for Economic Entomology

Grasshopper feeding on soybeans.

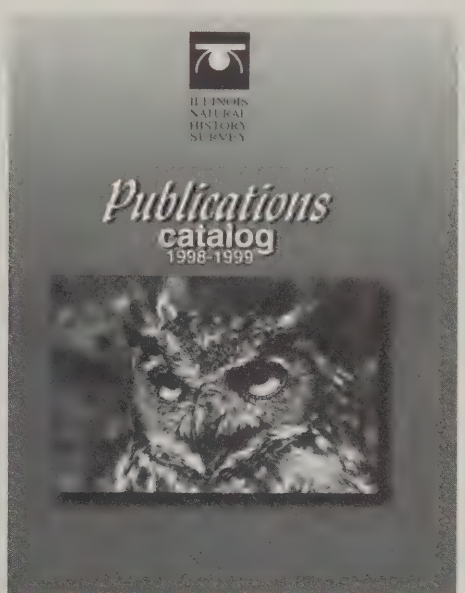
New INHS Publications Catalog

The 1998-1999 Illinois Natural History Survey Publications Catalog is now available. The catalog comes in two versions—paper and electronic.

To obtain a free paper copy, contact the following address or phone number:
Distribution Office
Illinois Natural History Survey
607 E. Peabody Dr.
Champaign, Illinois 61820
(217) 333-6880.

The electronic version of the catalog can be accessed via the Web at URL: <http://www.inhs.uiuc.edu:70/chf/pub/pub-catalog/spring98/>. You may also reach the catalog via the "News and Publications" link on the INHS homepage at URL: <http://www.inhs.uiuc.edu/>.

The INHS Publications Catalog contains listings and prices of all INHS publications that are currently in print. A convenient mail-in order form is provided in both the paper and electronic versions of the catalog.



Species Spotlight

Walking Stick

Susan Post

During the late 1800s the common walking stick, *Diapheromera femorata*, was such an abundant and destructive insect pest in Illinois that entomologists considered it economically important. Large populations of walking sticks stripped foliage from trees and underbrush and hung from bare twigs and branches in great clusters. A single walking stick could devour an inch-long, one-third-inch-wide strip of leaf in an hour. As forest feeders, walking sticks have preferred the leaves of hardwood trees, especially wild cherry, black locust, and oak. Today, walking sticks are not found in massive groups in Illinois but are still fairly common. They are curiosities that the average person will likely never see because of their excellent camouflauge.

Photo by Michael Jeffords, INHS Center for Economic Entomology

The common walking stick, Diapheromera femorata.

Walking sticks are related to grasshoppers, crickets, mantids, and cockroaches. Modern-day taxonomy places them in the insect order Phasmida. Illinois has five species of walking sticks with *Diapheromera femorata*, the common walking stick, the predominate species.

Walking sticks have elongate, cylindrical (sticklike) bodies with long slender legs and antennae. They usually have no wings and range in color from greenish to gray to brown. They move very slowly and sometimes remain motionless, appearing dead for long periods of time. With their camouflage and by feeding at night and resting during the day, walking sticks are rarely detected by other animals. If they should be sighted, the insect straightens out with its front legs and antenna extended to resemble a dead twig.

The common walking stick has incomplete metamorphosis—its life cycle consists of egg, nymph, and adult. The female will lay about 100 small (less than 3 mm in length), long, oval eggs that resemble plump beans. Females simply drop their eggs onto the forest floor while moving in the tree tops. During the early 1900s when the insect was common, the sound of the abundant eggs dropping in the forest was like the constant patter of rain. While the unprotected eggs would seem to be easy targets for parasites or predators, a species of ant is attracted to them and carries them off to their underground nests. The ants don't eat the eggs but instead consume an edible appendage on the eggs called the capitulum. The eggs still hatch normally after they have been dispersed and protected by the ants.

The eggs remain in the ground all winter and most will hatch during May. When first hatched, the young nymphs measure 4.5 mm and are a pale yellowish green. They will molt five times, and by August the walking stick nymphs have reached adulthood. The only changes from nymph to adulthood are increased size and a color change. Young nymphs are green to blend with vegetation; when the foliage begins to change, the nymphs' color changes to various shades of gray or brown. During nymphhood these insects can do something no other immature insect species can—they are able to regenerate lost limbs. At the time of a molt, the limb will be restored although it is sometimes smaller than the original.

As the insect matures, it moves higher into the forest canopy from the shrub and small tree layer to the tops of big trees. Finally, when the eggs begin raining, astute observers will know that a new generation of walking sticks has begun.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Objective: to understand that insects have different types of development.

Materials: multiple copies of "**Insects and Their Young**."

Vocabulary: larvae, nymph, pupal stage.

Comments: Insects exhibit different types of development. In incomplete metamorphosis, the egg hatches into a nymph that resembles the adult; the nymph grows and molts until it is an adult with fully formed wings. In complete metamorphosis, the egg hatches into a larva that is very different from the adult in both appearance and feeding habits. The larva feeds and grows. It then forms a pupa and transforms into an adult insect.

Procedure: On the following page, the column on the left contains adult insects and descriptions of the immature stages. Match the adult insects with the immature insects shown in the right column.

Answers: A=4, B=7, C=6, D=3, E=1, F=5, G=2

The Naturalist's Apprentice

Insects and Their Young

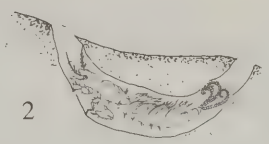
Carolyn Nixon

Many insects look very different and have different lifestyles as adults and immatures. Some immature insects, known as larvae, look nothing like the adults, and must go through a pupal stage to transform. Others, known as nymphs, resemble the adults but lack wings. As the insect grows and molts, it develops wing buds, and when the wings are fully formed, it is an adult. Match the adult insects on the left with the immature insects on the right.

A. Ant Lion. The larva makes pitfall traps in the sand to catch ants.

1

B. June Beetle. The larva is called a grub. It has a soft, white body, but strong legs and jaws. It feeds on grass roots.



2

C. Parasitic Wasp. The larvae are small grubs that feed on caterpillars.

3

D. Mosquito. The larva lives in the water and must come to the surface to breath through a tube on its posterior end.

4

E. Monarch Butterfly. The larva, or caterpillar, is boldly marked with stripes to advertise that it is not good to eat.

5

F. Grasshopper. The nymph is a miniature replica of the adult, only it lacks wings.

6

G. Mayfly. The nymph lives in the water and breathes with gills that run along the side of its abdomen.

7

ILLINOIS
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607 East Peabody Drive,
Champaign, Illinois
61820 USA

SIRIC

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associated arthropods. You can now access the database on the Web at <http://insectweb.inhs.uiuc. edu/Soy/SIRIC/index.html>. The objectives for this first two years of revitalization include:

1. Convert the database format from one designed for an out-of-date IBM mainframe platform that relies on custom programming to a user-friendly format that is accessible on multiple current computer platforms using commercially available software products.

2. Make the database in its new format available via the Internet and World Wide Web, and develop the search interface required to provide users of the new database with the same powerful searching capabilities that were previously available only to SIRIC's librarian.

3. Complete a large portion of the task of updating the content of the database and the reprint collection with material published since the database was last updated.

With the SIRIC database converted to a user-friendly format, valuable information can be made rapidly available to the agricultural and research communities. When insect outbreaks occur as a result of introductions of exotic species, expensive corrective action is usually necessary, and the longer the delay in taking action, the costlier the program. The SIRIC database, in tandem with the International Soybean Arthropod Collection (ISAC), can provide essential information to researchers and soybean producers on the identity of new pest species, alert them to weaknesses in their life cycles, and inform them of the most effective management strategies. This information conservatively could save two to five years of research time necessary to evaluate the problem and to implement corrective measures. Until 1990, the information contained in SIRIC was available and operational at an annual cost of about $^{1}/_{1,000}$% of the annual value of the Illinois soybean crop and an infinitesimal fraction of the value of the world soybean crop. The investment in this database is, therefore, extremely small compared to its value as a research tool, especially in the event of pest outbreaks.

Lynn Hanson, Soybean Insect Research Information Center, and Michael Irwin, Center for Economic Entomology

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ILLINOIS NATURAL HISTORY SURVEY

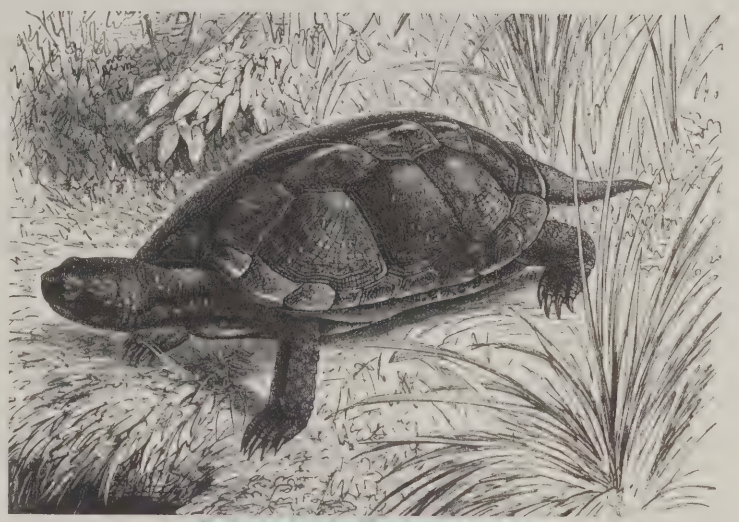
Reports

September/
October 1998
No. 353

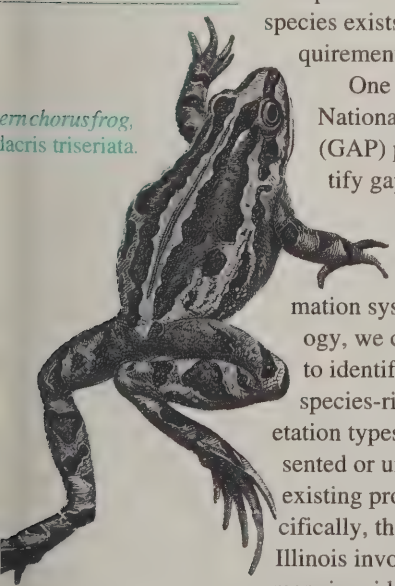
INSIDE

Mapping the Diversity of Amphibians and Reptiles in Illinois

Because Illinois is at the crossroads of several different biogeographic realms, it possesses a rich diversity of amphibians and reptiles. The Illinois Natural History Survey (INHS) and the Museum of Natural History (MNH) at the University of Illinois have an extensive representation of this diversity in their scientific collections. There are approximately 11,000 preserved specimens, collected from 1842 to the present, in these two collections. These collections are invaluable because they allow us to track individual species and overall species diversity through time and across a landscape that has been dramatically changed by agriculture. To maintain and potentially enhance this diversity, it is important to know where each species exists and its habitat requirements.



Red-eared slider, *Trachemys scripta*.



ern chorus frog, Pseudacris triseriata.

One of the goals of the National Gap Analysis (GAP) program is to identify gaps in the representation of the nation's biodiversity. Using geographic information system (GIS) technology, we can use digital maps to identify individual species, species-rich areas, and vegetation types that are unrepresented or underrepresented in existing protected areas. Specifically, the GAP program in Illinois involves vegetation mapping, identifying land stewardship management, and mapping distributions of mammals, birds, amphibians, and reptiles. Currently, we are concentrating our efforts on mapping the locations of Illinois specimens in the INHS and MNH amphibian and reptile collections.

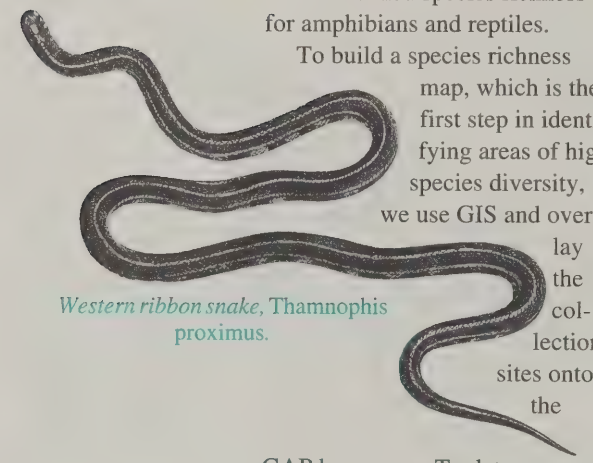
Our approach involves identifying a location for each specimen based on information collected with the specimen. Each specimen may have a "common" location description (e.g., 2 miles east of Champaign) or a legal description (e.g., section 6 of township 34 north, range 5 east), or a town name (e.g., Bement). Using our GIS and computerized U.S. Geological Survey quad maps called digital raster graphics (DRG), we are able to locate roads, streams, and other landmarks used in the location description to determine the collection site. We also have a computerized map of the township, range, and section information for the entire state. Using GIS, we can overlay this map layer onto the DRGs to determine the collection site from the legal description. When only a town name is available as the collection site, we use our GIS to match the location of the town hall in our computerized database of town names with the town name in the collection database. Using these various methods and employing GIS technology enables us to build a map of collection sites for all the amphibian and reptile specimens. Additionally, we assign an accuracy code that reflects how sure we are of our location assignment for each specimen.

Continued on page 2

Mapping

continued from front page

Each specimen collection site falls within a 635-km^2 hexagon, which is the mapping unit used by the GAP program. Hexagons were chosen over counties because they are equally sized and easily connect to adjacent states. It is within these hexagons that we determined species richness for amphibians and reptiles.

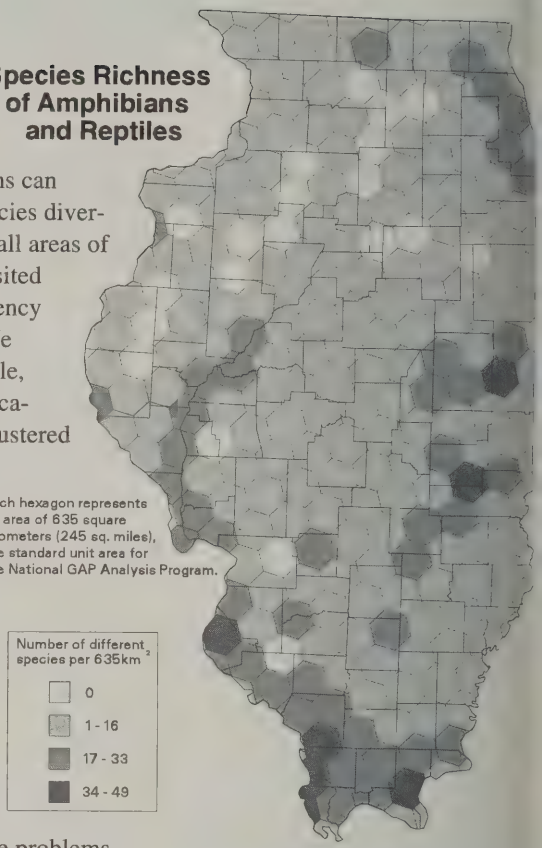


Western ribbon snake, Thamnophis proximus.

To build a species richness map, which is the first step in identifying areas of high species diversity, we use GIS and overlay the collection sites onto the GAP hexagons. To determine species richness, we sum up the number of different species that occur in each hexagon. From the species richness map we can identify species as well as groups of species that are not represented in the current network of management areas.

Northern fence lizard, Sceloporus undulatus.

Species richness maps based on preserved specimens in natural history collections can misrepresent species diversity because not all areas of the state were visited with equal frequency by collectors. We know, for example, that collection locations are often clustered around large cities, universities, or outstanding natural features. Some hexagons in the species richness map may have never been visited by collectors. In addition, there are problems with the scale at which the data are displayed. The hexagons cover a large area, which may not adequately represent the diversity of a small pond in someone's backyard.



Map of Illinois showing how the state is divided into hexagons for quantifying species richness.

It is important to be aware of these limitations; however, the ability to map the species richness of amphibians and reptiles for the entire state is a big accomplishment. Our next step will be to use our vegetation mapping and management practices on public lands to identify areas throughout the state that need better management to preserve the biodiversity of amphibians and reptiles in Illinois.

Jocelyn Aycrigg, Center for Wildlife Ecology; Chris Phillips, Center for Biodiversity; Tim Maples, Center for Wildlife Ecology; and Tom Kompare, Center for Biodiversity

Spotted salamander, Ambystoma maculatum.

A Perplexing Pest Problem in Peppers in Illinois

Over the past couple of decades the cultivation of sweet peppers has become a profitable business for some farmers in the southern Illinois floodplains of the Ohio and Mississippi rivers. In 1992 several growers in this area noticed dark brown lesions on their peppers in August. In 1993 the same lesions, accompanied by additional symptoms, led plant epidemiologists at the University of Illinois to conclude that a viral disease caused by the cucumber mosaic virus (CMV) was responsible. In 1993 some pepper fields were plowed under, and in 1994 at least one long-time grower of peppers stopped growing the crop because of the potential for crop loss by this virus. In 1995 evidence of CMV infection was seen at an increasing number of farms, including the largest pepper grower in the Midwest with over 800 acres of peppers. Significant crop losses occurred that season, and the long-term result has been that pepper cultivation has been reduced in the region with significant loss of revenue.

Photo by Darin Eastburn, Department of Crop Sciences, University of Illinois

Comparison of noninfected pepper (left) with one infected with CMV.

...virtual total crop loss can occur in peppers if the infection of the plants occurs early enough in the season.

CMV is transmitted by aphids in a simple manner. When an aphid lands on a plant it usually probes the plant with its mouthparts and by so doing can determine if the plant is an acceptable host. If the plant is not acceptable, the aphid will withdraw its mouthparts and fly to another plant where it also probes to test (taste) the plant. These probes are all that is necessary for the aphid vector to pick up CMV from an infected plant and transmit it to an uninfected one. Infestations of 100% and virtual total crop loss can occur in peppers if the infection of the plants occurs early enough in the season.

Epidemiologists from the University of Illinois have determined that the virus is present in at least two weeds common in the area, a *Physalis* sp. and *Solanum* sp., both in the Solanaceae or nightshade family. To move the virus into the pepper fields from these reservoir hosts, an appropriate aphid species would have to land on them, probe, pick up the virus, then move into the field, land on a pepper, and probe. In situations like this it is important to determine the identity of the aphid vectors as well as the reservoir host of the virus. Aphids were trapped in pepper fields during the 1996 and 1997 growing seasons and identified by a Survey entomologist. More than 80 species were present in these collections, of which 17 are known to be capable of transmitting CMV to peppers. To determine which species of aphids were vectors of CMV, over 4,000 individual aphids were collected as they flew over the pepper field. Each was placed on a separate virus-free pepper seedling and left for several hours to probe. Aphids were then removed and saved for identification. The seedlings were kept under aphid-free growing conditions long enough for symptoms to develop. Two of the plants developed symptoms; however, this is insufficient evidence to implicate any particular species as the primary vector.

Research into this problem is expected to continue for the next several years. The focus will be on determining the aphid species responsible for the transmission of CMV and the seasonal biology of the species. The potential for limiting the spread of the virus by weed control will also be explored. This ongoing research is a collaborative effort between scientists at the Crop Sciences Department at the University of Illinois and the Illinois Natural History Survey.

David J. Voegtlin, Center for Biodiversity

Database Gathers Taxonomic Information

Before the computer, scientists organized their data in notebooks, on note cards, or in their heads. If we were lucky, these observations were published in scientific journals or monographs for future generations to read and use as a reference. When taxonomists write papers describing the insects they study, they may look at as few as two or as many as several hundred, even thousands of specimens.

The information about insect specimens caught, pinned, and placed in museums is on minute labels attached to the pin impaling the specimen. It often requires either excellent eyesight or a magnifying glass to examine these labels, and at a minimum a good dissecting microscope to discern the pertinent features distinguishing one species from another. Now, with computers on the desks of most scientists, this suite of information can be logged into a database for easier retrieval. A database stores information about a group of things (in our case, the fly family Therevidae) in records, one record per fly. We tag each insect with a unique number and add that label to those already on the pin so that in the future researchers may retrieve the information from the database for their studies. We have over 50,000 therevids cataloged to date by undergraduate students working with our project.

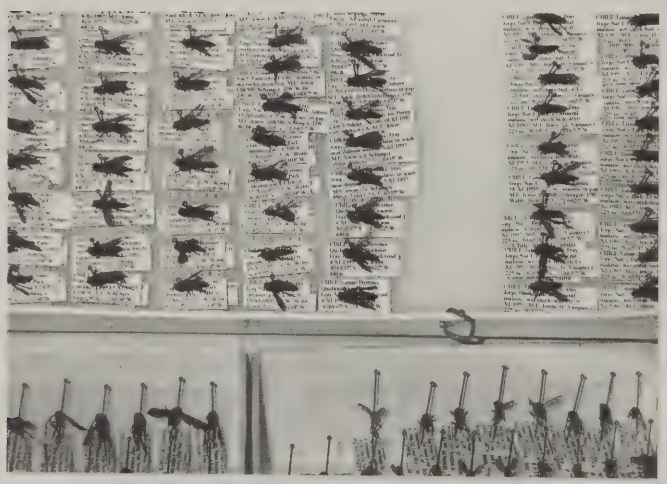


Photo by Gail Kampmeier, INHS Center for Economic Entomology

Specimen collecion tray containing therevid species in INHS Insect Collection.

Each record is composed of many fields, or pieces of information that we may want to retrieve about that fly. Where was the fly collected? When? By whom? Under what conditions and with what equipment? Was it collected as an adult or reared to that stage? Was it associated with a plant or another organism such as a predator? What is the scientific name of the specimen? Has anyone ever called it anything else? Is it on loan from a museum or collection? Has it been illustrated? What is its sex? Is the specimen missing body parts? Has it been ground up for molecular studies? Has it been dissected? Has someone written about it in the literature? Is it a type specimen, used as a model for the description of the species? Most of this information can be gathered from looking at the specimen and the labels attached to its pin.

The National Science Foundation (NSF) recognized the importance of getting taxonomists to record their data electronically in its granting program "Partnerships for Enhancing Expertise in Taxonomy" (PEET). In addition to training the next generation of taxonomists and providing funds for the study of little-known groups of organisms, NSF has emphasized the need to electronically catalog and distribute information about the organisms we study. As part of our project on the fly family Therevidae (stiletto flies), we examined existing systems for cataloging specimen data and decided that many existing customized systems were at once more complex (requiring a dedicated computer programmer to create and maintain) and not responsive enough to our demands for special features.

Many scientists avoid cataloging their work because they think they must be computer geniuses to create a database. With today's database applications, this no longer has to be the case. Three years ago, we chose an off-the-shelf database engine, FileMaker™ Pro, that was known for its ease of use and its ability to work in both Macintosh™ and Windows™ environments. With a rudimentary knowledge of this database engine (we are entomologists, not computer programmers) we developed, in collaboration with taxonomists, five files (specimens, taxa, lots, museums, people) that were connected by lookups and formed the original basis for recording information about therevid specimens. Over the last three years, the static lookups have become dynamic relations, where changing the data in one place changes it everywhere those data are referenced. The number of related files has swelled from 5 to 24, and in 1998 the database structure finally gained a name: *Mandala*. The word means interconnectedness and typifies these interrelated files that are linked by specimen number, taxon name, and/or literature citation. The system includes context sensitive help at both the file and field level (clicking on the help button while in a field takes the user to specific help for that field). There is also a system for electronic recording and tracking of questions and their resolution.

Do scientists need everything we have developed over the last three years to do their systematic research? It is likely they could

Continued on last page

Channel Catfish Populations in the Upper Mississippi River System

The channel catfish (*Ictalurus punctatus* Rafinesque 1818), an important component of the Upper Mississippi River System (UMRS) fish community, is abundant and makes up a significant portion of the total fish biomass of our large rivers. This species is avidly sought by both sport anglers and commercial harvesters. One of the goals of the Long Term Resource Monitoring Program (LTRMP) is to monitor and evaluate long-term trends in the populations of the channel catfish.

From the inception of the program in 1989 to the present, the field stations of the LTRMP have been monitoring fish populations in several types of aquatic habitat in six reaches of the UMRS (the UMRS includes the Illinois River and the upper Mississippi River). These habitats include tailwater just downriver of a navigation dam, the impounded area just upriver of a dam, flowing side channels, the main channel, and backwater contiguous areas that are at least seasonally connected to the river main channel. The Illinois Natural History Survey operates the two LTRMP stations in Illinois: one on the La Grange Reach of the Illinois River and the Great Rivers Field Station on Reach 26 of the Mississippi River (Figure 1). By combining data from the two Illinois stations with data from the other four stations, we can assess the status of channel catfish populations throughout much of the UMRS.

One problem in making population assessments is that each type of sampling gear (different types of nets and electrofishing boats) is selective for certain sizes or species of fish. Moreover, the vulnerability of fish to the gear varies with environmental conditions, such as water depth, current, and turbidity, and biological factors, such as the presence of submersed vegetation. Hence, it is important to sort out what changes in fish catch are attributable to real changes in the fish populations and what changes are due to other factors. To obtain a variety of sizes of fish under a variety of environmental conditions, the LTRMP utilizes several different gears for population assessment, including day and night electrofishing, small and large hoop netting, fyke netting, seining, and trawling. The multiple gears are employed using standardized methods. The gears that have captured the most channel catfish are hoop nets (small and large), accounting for 68.1% of the total catch. Another 25% have been caught using fyke netting, day electrofishing, and trawling.

More than 42,000 channel catfish have been captured, measured, and returned to the rivers by LTRMP fish biologists. There is a striking variability in catch (and presumably abundance) of channel catfish from one reach to another and usually among habitat types within a reach. The La Grange Reach has yielded 15,912 fish (38.1%), the largest share of the combined catch, while Reach 4, along the Minnesota portion of the upper Mississippi, has yielded the least, only 1,707 (4.1%). We have noticed a strong south to north gradient in day electrofishing catch rates. During nearly all years of sampling, the catch rates have been significantly higher at Reach 26, Open River Reach, and La Grange Reach than at Reaches 4, 8, and 13. Catches by electrofishing have ranged from over 10 channel catfish per hour at La Grange Reach in 1997 to less than 1 per hour at Reach 4 in 1994. Catfish prefer habitats with woody debris, bank cavities to hide in, and moderate currents, so it is not surprising that more than two-thirds of the fish collected by all of our gears have been in side channel and main channel borders (hence the common name "channel" catfish) while only 10% have been found in backwater and impounded habitats.

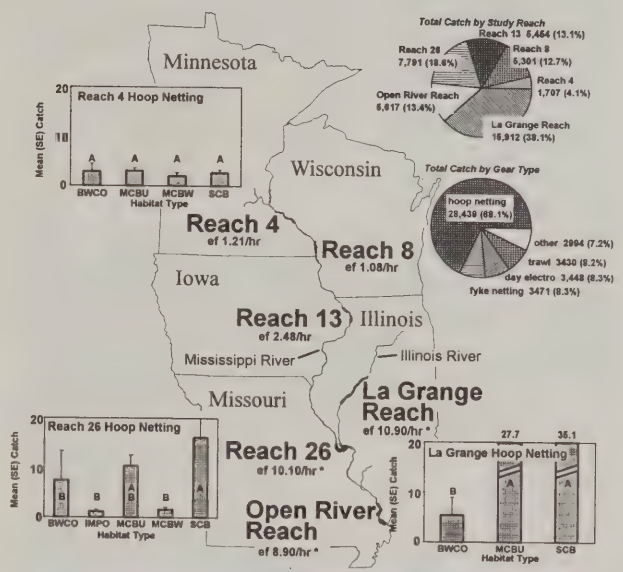


Fig. 1. Map indicating the six reaches of the Upper Mississippi River System, including two operated by INHS.

In addition to differences in abundance of channel catfish among reaches and habitats, there are marked differences among years in production of young fish. In 1991, for example, there were large numbers of young channel catfish in nearly all of the study reaches. Sampling the same reaches year after year allows us to "watch" the fish grow. Channel catfish from the "class of '91" were first measured when they were less than 4 inches long; by 1997 many were over 20 inches long—an excellent growth rate for the Midwest.

Ongoing research involves assessment of effects of environmental conditions on sampling efficiency so that we can compensate for these effects and better assess the effects of environmental variations on the fish populations themselves. For example, the low catfish yields in the Minnesota reach of the Mississippi may be attributable to more abundant submersed vegetation there. The vegetation not only hides and protects young catfish from predators but also from fish biologists and their sampling gear! Once we can adjust catch rates for differences in sampling efficiency, we can assess the true abundance of catfish and other fishes, and associate differences in abundance with differences in habitat and water quality, seasonal water regime, and other factors, including natural and harvest mortality. Such information is vital in setting harvest regulations and managing rivers to sustain catfish populations.

Todd M. Koel, Ruth M. Sparks, and Richard E. Sparks, Center for Aquatic Ecology

Species Spotlight

Halloween Spider

Susan Post

The Halloween spider, as it is known in central Illinois, is also called the marbled spider or the spectacled spider. The common name refers to the pattern found on its abdomen. The color pattern ranges from white, to yellow, to orange with a dark pattern of grays and blacks. Black lines are also found around the light spots.

Photo by Michael Jeffords, INHS Center for Economic Entomology

The Halloween spider, Araneus marmoreus Clerck.

By early fall the females have matured and are 1/2 to 3/4 of an inch long. They can be found in their webs until cold weather, usually late November. The males are much smaller, about half as big as the females, and live only through October. During October, the female will lay her egg sac, which is about half an inch in diameter. This egg sac is a flattened sphere of loose white silk and contains over 600 orange eggs.

This colorful spider is found throughout the United States and Canada, absent only from the desert Southwest. One reason for its absence from the desert is the spider prefers a habitat with some moisture, such as swamps and along the banks of streams. Usually the spider's web is made in shrubs and tall grass; occasionally it is found in the low branches of trees in moist woods.

The Halloween Spider is related to the familiar black and yellow garden spider. Both are known as orb weavers, referring to the type of web they spin. Their webs are vertical, two-dimensional snares known as orb webs. The orb web has been called "a refinement of art for a mess of flies!" Almost invisible in ordinary light, sticky lines stretch across space as a tough but yielding net into which flies and other choice prey blunder. The plane of the web is practically vertical and a single line connects the hub (the center of the web) with the retreat (a place above the snare, where the spider spends the day). For the Halloween spider, the adult retreat consists of leaves bound together with silk. Young Halloween spiders make their retreats entirely of silk.

While hiking in the fall, take time to look for this colorful spider. To see this unique creature, which resembles a tiny jack-o'-lantern, within its leafy retreat is far better than curling up with that large bag of trick-or-treat candy—and it's far easier on the waistline.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Spider Web Maze

Objective: to understand that not all of the lines of a spider web are sticky.

Materials: multiple copies of "Spider Web Maze."

Comments: In a spider web, the lines that radiate from the center of the web, like the spokes of a wheel, are not sticky. These are the spider's paths around the web. If the spider were to walk on the sticky lines that circle the web, it could get caught in its own web.

Procecure: On the following page, trace the path that the bee can follow along the thinner lines of the web. Find a path from the center of the web to the end of one of the radiating lines that leaves the web.

Solution

The Naturalist's Apprentice

Spider Web Maze

Carolyn Nixon

Spider Web Maze

The bee has accidentally flown into the spider's web, but it was lucky enough to land in the middle where none of the lines are sticky. Help the bee find a way out of the web by following the non-sticky lines, but be careful! It must not step on the sticky lines (those that are bolder) or it will wake the spider, sleeping in its nest.

ILLINOIS
NATURAL
HISTORY
SURVEY
607 East Peabody Drive,
Champaign, Illinois
61820 USA

Database

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Illinois Natural History Survey Reports is published bimonthly by the Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820. Headquartered on the campus of the University of Illinois at Urbana-Champaign, the Survey is a division of the Illinois Department of Natural Resources.

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use more, not less. The system is flexible enough that parts of it may be used and others ignored. If a better system comes along, the data can be exported to it. Specific fields, customized for the user, can be exported for reports or monographs. Additional fields may be easily defined; the intent of a field may be modified (e.g., elevation to depth, as we did for another NSF PEET project focused on tiny deep sea mollusks called aplacophorans). Pop-up lists may also be modified to reflect different collecting methods and geographical reference points (oceanographic basins rather than geopolitical units). When modifying the databases to work with another group of flies, acrocerids that are parasitic on spiders, we found we needed to document more than one specimen associated with another (e.g., one spider with many parasites). This addition may not be immediately useful to our project, but no doubt provides a generalized improvement to our database structure.

Why is it important to have all of these data on the computer? Specimens are often scattered in museums around the world. Scientists studying them may have temporary access to them, but then must return the specimens after study. By recording the data electronically, it is easier to retrieve only those pieces of information that are relevant to the questions being asked. It is also easier to make these data available via CD ROM or on the World Wide Web to a wider audience, such as those working on biodiversity or agroecology issues. Later this year we hope to have some of the published information from our databases searchable on the Web.

http://www.inhs.uiuc.edu/cee/wwwtest/therevid/stiletto_fly.html

Gail E. Kampmeier and Michael E. Irwin, Center for Economic Entomology

ILLINOIS NATURAL HISTORY SURVEY

Reports

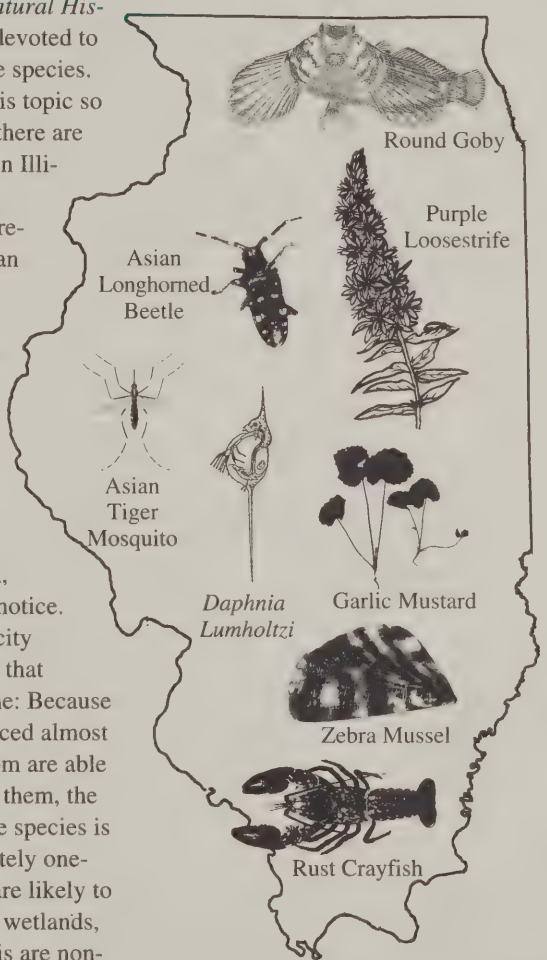
November/
December 1998
No. 354

INSIDE

Illinois Under Siege

This issue of *Illinois Natural History Survey Reports* is devoted to a single topic—invasive species. Because we consider this topic so important and because there are many invasive species in Illinois, this issue is more than twice as large as previous ones so that we can adequately cover the topic. Even our school activities column, "The Naturalist's Apprentice," is designed to help answer the question, What is a pest?

Each new invasive species receives a moment of media attention, then fades from public notice. Such intermittent publicity masks a general pattern that should concern everyone: Because new species are introduced almost every year but we seldom are able to completely eradicate them, the total number of invasive species is increasing. Approximately one-third of the plants you are likely to see in most woodlands, wetlands, and grasslands in Illinois are non-native species. In the aquatic realm, the Great Lakes illustrate virtually every problem associated with transfers of species by humans, culminating in an altered ecosystem that no longer maintains itself but requires costly human intervention. The invasive species described in these articles are only a few of the more recent introductions that Survey scientists are seeking to control.



What is an invasive species? There are at least 4,500 known species of foreign origin that have established free-living populations in the U.S. Some of these are beneficial animals and plants that were intentionally introduced, such as cattle and wheat, and are not considered problems. There are others, however, that displace beneficial native species, carry diseases and parasites that threaten human health and the health of domesticated and native species, and cause economic damage (e.g., the zebra mussel clogs water intakes of industrial and municipal water plants). Not every species that is introduced to the U.S. survives and establishes self-maintaining populations. The terms "invasive" or "weedy" are generally used for species that out-compete and displace native species, often becoming the dominant species, not just in a numerical sense, but also in terms of altering environmental conditions. For example, dense beds of zebra mussels can use up enough oxygen in rivers to stress not only themselves but also native fishes, mussels, snails, and aquatic insects.

Invasive species, as you will learn from this issue, are an old and continuing problem in Illinois. Some species, such as purple loosestrife, have been around for more than a century. Others, such as the Asian longhorned beetle, arrived only this year; others, no doubt, will come in the months and years ahead. At INHS, we are constantly vigilant to detect their arriv-

Continued on back page

Great Lakes Invasion

Why so many invaders in the Great Lakes? About 140 plant and animal invaders have become established in the Great Lakes since the mid-1800s. Why have so many species successfully invaded these lakes? Biological invasions are not predictable but we have learned about what conditions make it more likely that invasive species may become established in ecosystems. These conditions include historical isolation of native species, high levels of human disturbance, easy invasion routes, and disruption of the native community. The Great Lakes were isolated from many source populations during the last major glaciation about 10,000 years ago and so do not contain a diverse set of native species. Human disturbance has increased since European settlement. It has included clear cutting and farming practices that increased sedimentation and turbidity, industrial pollution, urbanization, intensive commercial fishing, and the intentional introduction of certain species. The Great Lakes also provide easy man-made access for invaders through canal systems linking the lakes with both the Atlantic and Mississippi drainages and through extensive worldwide shipping traffic. Native communities have been disrupted almost continuously since the mid-1900s by invading sea lamprey, alewife, and zebra mussel, resulting in the extirpation or extinction of many native species. This disruption has led to additional invasions that may not yet have run their course. As a result, the Great Lakes is one of the world's most easily invaded ecosystems, a status unlikely to change in the near future.

There are so many introduced species in the Great Lakes that some biologists argue that it is now a man-made aquaculture system. For example, sport fisheries in the Great Lakes depend on salmon and trout (Family Salmonidae) that are not native to the lakes but are artificially propagated in hatcheries (coho, *Oncorhynchus kisutch*; chinook, *Oncorhynchus tshawytscha*; rainbow or steelhead, *Oncorhynchus mykiss*; brown trout, *Salmo trutta*). The salmonids were introduced originally to control alewives (*Alosa pseudoharengus*), which entered the Great Lakes after the Welland Canal was completed in 1829. The canal circumvented Niagara Falls, a natural barrier to migration of fishes from the St. Lawrence River and Lake Ontario into the other four Great Lakes. The alewives did not become a problem until the 1960s, when populations exploded, then died in huge numbers, fouling swimming beaches and clogging water intakes. Previously, alewives apparently were kept in check by a predator native to the Great Lakes, the lake trout (*Salvelinus namaycush*), and perhaps by nine species of native whitefishes (genus *Coregonus*) that competed with alewives for food (zooplankton).

Unfortunately the lake trout and the whitefishes were decimated a decade earlier (1950s) by yet another invading species, the predatory sea lamprey (*Petromyzon marinus*), which attaches to large fishes with a sucker mouth armed with teeth and then consumes flesh and fluids from its prey. The sea lampreys do not attack small fishes, such as alewives, which initially were freed from predation and competition. Although the lampreys attack the introduced trout and salmon, the parasites are now kept in check by poisoning their larvae in the streams and rivers that run into the Great Lakes, or by using electric barriers to keep adults out of their spawning streams. The larvicide is highly toxic to the sea lamprey and less toxic to other aquatic species and its use is limited to the reaches of streams where lampreys are known to spawn. The research and control program is costly (estimated at $10 million annu-

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Great Lakes

continued from previous page

ally by the President's Office of Technology Assessment in 1992), but is considered necessary because the direct and indirect effects of losing the fisheries could exceed $500 million annually.

The story of invasive species in the Great Lakes illustrates several important principles. First, invasive species can change self-maintaining ecosystems into ecosystems that have to be maintained by humans. In the Great Lakes, the supply of species highly valued by humans (sport and commercial fishes) previously provided free by the ecosystem now has to be maintained by hatcheries and lamprey control programs. Other goods, such as water for industrial or municipal use, can become more costly because intakes and pipes have to be treated to remove fouling organisms, such as zebra mussels. Second, there are uncertainties and risks associated with control programs. For example, species introduced to control other introduced species (e.g., chinook salmon to control alewives) can indirectly cause other problems. In this case, chinook salmon are affected by bacterial kidney disease (BKD), which sometimes reaches levels that kill these important stocked predators. Concern is also growing that chinook salmon may have increased the prevalence of BKD to the point that it could affect native species of the genus *Coregonus*. Third, the increasing number of invaders can have progressive impacts on native species. Native yellow perch (*Perca fulvescens*) persisted in the face of competition and predation from alewife but have declined dramatically since 1988 and may not have been able to withstand the additional pressure placed on their food resources by two recent invaders, the zebra mussel and spiny water flea (*Bythotrephes cederstroemi*). These principles demonstrate that costs of invasive species are real both in ecological and economic terms and demonstrate the importance of research conducted by Survey scientists to understand how we can prevent additional invasions, control invaders already here, and prevent their spread.

John Dettmers, Center for Aquatic Ecology

The Bighead Carp (*Hypophthalmichthys nobilis*) in Reach 26 of the Mississippi River

The bighead carp, *Hypophthalmichthys nobilis*, is a large, deep-bodied cyprinid introduced from eastern Asia. This species is a filter feeder that strains planktonic organisms with long comb-like gill rakers.

Three specimens of *H. nobilis* were collected in 1986 and 1987 from the Mississippi River in Hancock and Henderson counties, Illinois, and we collected specimens in Reach 26 of the upper Mississippi River (UMR) near Alton, Illinois, during routine fish sampling beginning in 1991. *Hypophthalmichthys nobilis* is now well established and common in certain habitats in Reach 26. Young-of-the-year fish in our collections indicate that successful reproduction is occurring. Specimens of *H. nobilis* have been reported from the Ohio River and from several streams in Arkansas.

Nothing is known of the effects that this exotic species will have on North American rivers or their fisheries. Retail acceptance of *H. nobilis* products has been reported, but the economic impact on commercial fisheries has not been studied. Local markets for *H. nobilis* products have not developed. Also, *H. nobilis* is considered a nuisance by the commercial fishermen that we interviewed.

The biological impact of *H. nobilis* on the Mississippi River is unknown. Further research on the potential impact of *H. nobilis* on other filter-feeding fishes, such as the paddlefish (*Polyodon spathula*), bigmouth buffalo (*Ictiobus cyprinellus*), and gizzard shad (*Dorosoma cepedianum*), is needed. We know, however, that *H. nobilis* is frequently caught with *P. spathula* in main channel habitats, which suggests that these two species may have similar requirements.

Photo courtesy of Amy Ratcliff

Eric Ratcliff of the INHS Great Rivers Field Station in Alton holds a bighead carp from the Mississippi River that literally jumped into his boat.

John K. Tucker, Frederick A. Cronin, Jeffrey Stone, and Timothy B. Mihuc, Center for Aquatic Ecology

Zebra Mussel/Unionid Interactions: Remediation Strategies[1]

The zebra mussel, *Dreissena polymorpha*, is a small (up to 40 mm total valve length) bivalved mollusk native to rivers near the Caspian and Ural seas. Its life cycle includes a free-floating larval stage followed by juvenile and adult stages where the mussel is attached by byssal threads to firm substrata. These two life-history traits contribute to the success of zebra mussels in colonizing much of central Europe and North America.

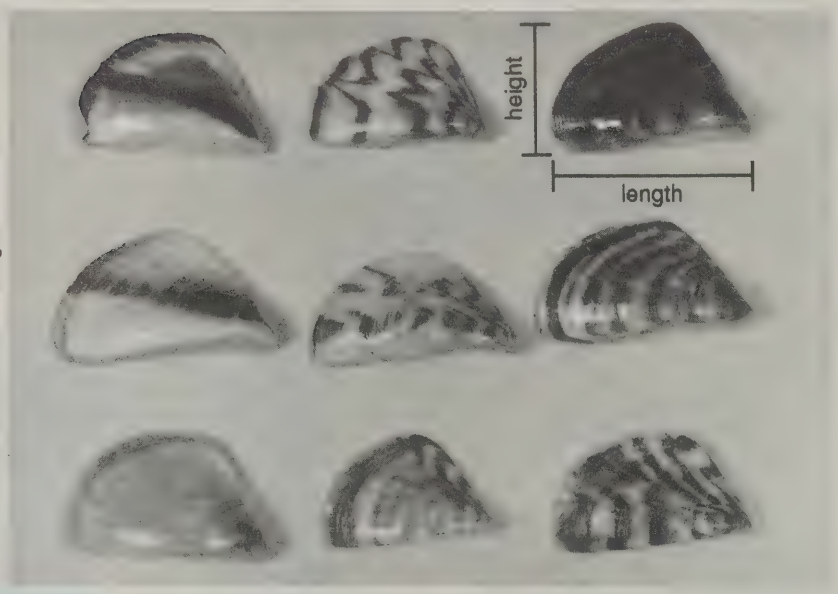

Photo from INHS image archives

Zebra mussel specimens from INHS Mussel Collection.

In North America, the zebra mussel was first reported from the Great Lakes in 1988 and likely was introduced during 1985–1986. Initial concern about the negative effects of zebra mussel colonization on unionid bivalves native to North America has been largely born out in the Great Lakes region. Similarly, colonization of the Mississippi River drainage will also likely lead to dramatic changes in unionid demography in that system.

A number of remediation strategies have been proposed in anticipation of the detrimental impact of zebra mussels on unionids. Suggested remediation strategies include enhancing predator/prey interactions, translocations of unionid stocks, manually cleaning zebra mussels from the shells of individual unionids, and natural refugia. A review of each strategy follows.

A number of predators include zebra mussels in their diets. For instance, several species of crayfish will prey on zebra mussels in the field and in the laboratory, and a map turtle (*Graptemys geographica*) also consumed zebra mussels in the laboratory. Several North American fish are likely to prey on zebra mussels; however, field studies have been conducted only on the freshwater drum, *Aplodinotus grunniens*, and the common carp, *Cyprinus carpio*. Regardless, the impact of fish predation on zebra mussel density and demography is unknown because few experimental studies have been conducted.

In contrast, the effects of diving-duck predation on zebra mussels have been studied experimentally. Generally, these studies find that duck predation has important but usually temporary effects on zebra mussels. Zebra mussel density may be reduced when ducks are present, but then mussel numbers rebound after the ducks migrate out of the area.

Although predation may have an impact on zebra mussels given the large number of potential predators, predation has not prevented zebra mussel impacts on native unionids in areas extensively colonized by zebra mussels. In any case, resource managers should act to prevent declines of and where appropriate encourage increases in species known to be zebra mussel predators as a remediation strategy.

Unionid translocation entails moving individual unionids from waters colonized by zebra mussels to areas where zebra mussels would not be expected to colonize, such as artificial ponds, captive holding facilities (e.g., fish hatcheries), or other natural waters. Translocation of unionids has a long history but recently it has been used to shelter selected rare species from the effects of pollution.

Continued on next page

[1] This report represents a brief summary of research conducted by INHS scientists and other researchers around the world.

Zebra Mussels

continued from previous page

Translocation would be of little use in maintaining unionid species diversity unless suites of species can be sheltered. Thus, application of translocation strategies is complicated by the lack of knowledge about species-specific requirements for survival and propagation. Moreover, survival of some species may be low in translocations.

Research suggested that periodic removal of zebra mussels from unionids would allow unionids to survive in habitats where survival and reproduction are successful despite heavy zebra mussel densities. Moreover, cleaning can be applied to all members of the fauna, thereby preserving diversity. Also in this study, experimental evidence demonstrated improved survival for cleaned unionids compared to those left uncleaned. However, the potential costs in human effort and in habitat disturbance needed to use this strategy were not addressed.

Ponds and other artificial habitats have been used to shelter unionid mussels from the adverse effects of zebra mussel colonization; however, the efforts required to use them are significant.

A recent study demonstrated that some local habitats, such as river backwaters, may act as natural refugia for unionid mussels. Researchers defined such refugia as sites where unionids continue to live in the presence of zebra mussel colonization. They further noted that such refugia would be needed only in a few areas when protection of unique unionid species is the primary objective.

Identification of natural refugia has been haphazard. Natural refugia for unionids have now been reported in an Illinois River backwater, in nearshore firm compacted sand habitat in Lake Erie, and in a Lake Erie wetland. Ideally, a model to identify potential natural refugia should be developed, and this model development should be a high priority because protection of potential natural refugia requires little additional effort.

It seems likely that discovery, study, and protection of natural refugia will be the best way to maximize conservation of unionid diversity. Nonetheless, the brief overview of potential mitigation strategies highlights the need for continued research. In particular, an understanding of the impact of fish predation on zebra mussels is needed. Likewise, development of a model to help identify natural refugia on a local scale is extremely important. Until these research needs are realized, any action that delays or reduces unionid mortality should be investigated.

John Tucker and Timothy Mihuc, Center for Aquatic Ecology

Predation May (or May Not) Work to Control Zebra Mussels

Predation by native species as a biological control of invasive species is usually limited. Native predators may not be adapted to utilizing the introduced organisms as forage. Predation on zebra mussels, *Dreissena polymorpha*, provides a good example of the complex response of natural predators. Soon after their introduction, zebra mussels reached high densities and became strong competitors with lower trophic levels. Several organisms, such as diving ducks, crayfish, eel, common carp, pumpkinseed, European roach, and freshwater drum, have been found to consume zebra mussels. Several other fish species are listed as potential predators of zebra mussels because of their historic consumption of other native molluscs. There is little evidence, however, of whether or not the potential native predators benefit by consuming zebra mussels or if their predation will serve as a biological control. In a study focused on catfish predation on zebra mussels in the Mississippi River, we investigated these relationships with blue catfish (*Ictalurus furcatus*) and channel catfish (*Ictalurus punctatus*).

Due to their historic consumption of native mussels, channel catfish were hypothesized to feed on zebra mussels whereas blue catfish were not. We found the occurrence of zebra mussels in the gut to be the opposite of what was expected. Over 65% of the blue catfish sampled had consumed large numbers of zebra mussels, whereas less than 15% of the channel catfish consumed zebra mussels. Furthermore, fish consuming zebra mussels were almost always 200-350 mm in size. We estimated the percent digestion of zebra mussels in the gut and found a great deal of variation in conversion rates. Many mussels pass through the gut and were found completely intact in the intestine. Bioenergetics work is needed to investigate digestive mechanisms because our data suggest that only fish that select exclusively for zebra mussels are successfully utilizing them as prey. It does not appear that any species has been successful in controlling zebra mussels in North American waters. Instead, the response of natural predators to invasive species continues to exceed our knowledge of predator/prey relationships. Additional research is needed to investigate the impact of invasive species and the bioenergetic benefit to native predators.

Randy M. Claramunt, Dave Wahl, Chad Dolan, John Dettmers, and John Tucker, Center for Aquatic Ecology

The Round Goby: An Example of the "Perfect" Invader?

The round goby, *Neogobius melanostomus,* is the most recent exotic fish (along with its cousin the tubenose goby, *Proterorhinus marmoratus*) to invade the Great Lakes. Introduced from their native range (the Black and Caspian seas) via ballast water, round gobies are small, benthic, soft-bodied fish that look similar to native sculpins, but can be identified by a black spot on their anterior dorsal fin and by fused pelvic fins in the form of a suctorial disc. First discovered in 1990 in the St. Clair River near Detroit, round gobies quickly spread and by 1995 had been reported in all five of the Great Lakes with population numbers reaching high densities in many areas in Lake Erie and Lake Michigan.

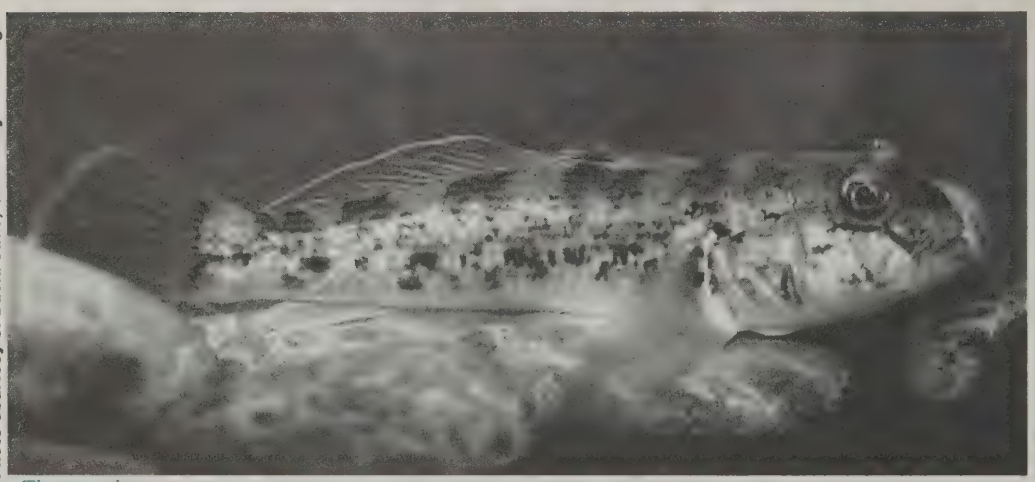

Photo courtesy of David Jude, University of Michigan

The round goby, Neogobius melanostomus.

Certain aspects of the round goby's biology provide us with an example of what the "perfect" invader is and why gobies may have been pre-adapted for live transport in ballast water of trans-oceanic ships. These same qualities will allow for their further expansion in North America, with the potential to threaten not only the Great Lakes aquatic communities but also their tributaries and other connected watersheds as well. The following adaptive features that gobies possess can be useful in determining what makes an invader successful and may predict who else could be a potential invader.

First, the round goby grows up to 10 inches and is a very aggressive, robust fish that is highly territorial and very competitive for food, shelter, and spawning areas. This competitive nature along with its larger size has already allowed it to displace smaller native benthic fish, such as the mottled sculpin (*Cottus bairdi*) and logperch (*Percina caprodes*), from some areas of the Great Lakes. Second, gobies can survive under a wide range of environmental conditions including fresh or salt water (40.5% saline), water with low dissolved oxygen and high levels of pollution, and also water from -1 to 33°C. Round gobies can also live in a wide range of habitat types, such as sandy or silty areas and macrophyte habitats, although they prefer rock, cobble, or riprap habitat. Third, gobies are voracious foragers with a very diverse diet comprised mostly of benthic invertebrates including zebra mussels, but may contain smaller fish and fish eggs. The use of zebra mussels in their diet provides gobies with a competitive advantage by giving them a food supply most native fish do not utilize. Round gobies also have a well-developed lateral line system that gives them the ability to feed at night. Finally, gobies spawn every 18-20 days and potentially up to six times during a breeding season. This reproductive pattern gives them an ecological advantage over native species which usually spawn only once.

Characteristics such as propagule pressure, suitability of habitat, and success in previous invasions can be valuable predictors for the success of a particular invasion. Round gobies have demonstrated that they possess these and other important characteristics, such as survivability in unfavorable conditions, adaptability to a new environment, territorial behavior, and other competitive advantages over native species that have allowed them to become an excellent

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Perfect Invader

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invader. The question is, How far and fast will they spread and what impacts will they have?

Research by Survey scientists shows gobies can survive at least several weeks at temperatures as high as 33°C and optimal growth for round gobies occurs near 24°C. These results for temperature tolerance are very similar to those of zebra mussels, which are widely distributed and have spread as far south as New Orleans. In addition, with zebra mussels present, gobies are given a preferred food item with suitable habitat already present upon arrival to new areas. Based on this and temperature tolerance, if gobies are able to spread to the Illinois River from Lake Michigan, their range could potentially expand to the Mississippi River, thus giving them access to much of the interior of North America. It remains to be seen how fast gobies will spread, or if a proposed dispersal barrier in the Chicago Ship and Sanitary Canal will stop round gobies from spreading too far downstream in the Illinois River.

With optimal growth for round gobies occurring near 24°C, it is highly possible they will be more successful in streams and rivers, where their greatest impacts on native species could be felt. Since round gobies have already had negative impacts on sculpin and logperch populations in the Great Lakes, biologists fear that similar impacts may occur with darters should gobies continue to spread. Survey scientists have conducted competition experiments among round gobies and both greenside (*Etheostoma blenniodes*) and johnny darters (*E. nigrum*) in artificial streams and enclosures placed into small ponds. Research measuring growth of darters with gobies present or absent indicate trends toward negative impacts on darters by round gobies. Also, results provide evidence that gobies are equal or better competitors than are darters with fellow darters.

Because round gobies reach such high densities and are known to eat the eggs of other fish, researchers are also concerned about possible predation by gobies on eggs of nesting sunfishes during spawning periods. For this reason, experiments were also conducted at the Illinois Natural History Survey in which round gobies were added to large cattle tanks with spawning pumpkinseed (*Lepomis gibbosus*) and green sunfish (*L. cyanellus*). Sunfish nests were then filmed with video equipment to observe if round gobies would eat sunfish eggs or even attempt to do so. The video showed that round gobies will raid nests and successfully prey on sunfish eggs, sometimes even when the guarding male sunfish is present. It is not known from these results how significant an impact gobies could have on overall nesting success of sunfish; however, it appears that guarding the nest successfully comes at a high price energetically for the male sunfish.

> Certain aspects of the round goby's biology provide us with an example of what the "perfect" invader is ...

There are many other ways in which round gobies could have major impacts on stream and river communities as predators, prey, or as competitors with native species. It is extremely important that more work be done in this area to help understand what impacts round gobies will have as their invasion continues to new areas. Since 1995, round gobies have been found in other areas of the Great Lakes, including a discovery as recently as this summer of large numbers of gobies living in Lake Superior near Superior, Wisconsin. They have also expanded their range to live much farther inland in both the Shiawassee and Flint rivers near Flint, Michigan. Most importantly, perhaps, gobies are now poised to invade the Illinois River system, having been found to exist at least 15 miles inland from Lake Michigan in the Cal-Sag Channel of Chicago. If the round goby and other aquatic invaders, such as the Eurasian ruffe, the sea lamprey, and the zebra mussel, that have similar qualities suited for invasion could be used as a model, we may be able to better predict what invaders will be successful or what other foreign animals could be potential candidates for future invasion, and possibly stop an invasion before it happens.

Round goby drawing by Martha Kneuer, INHS Center for Aquatic Ecology

Cordell H. Manz, Center for Aquatic Ecology

"Clean Sets in Clean Ground"—Successful Management of the Imported Crucifer Weevil on Horseradish

Illinois leads the nation in the production of horseradish, a spicy cruciferous root used as a condiment. Although a minor crop grown primarily in the American Bottom region of southwest Illinois, horseradish contributes nearly $4 million to the state's agricultural economy. Of the over 50 insect species identified from horseradish in 1955, most were only occasional pests and none produced serious injury directly to the roots. A new insect found in the late 1970s, however, threatened that situation. In May 1977, a Survey entomologist working in the East St. Louis area was called by a grower to examine insect larvae and severe tunneling in harvested roots. Once reared and field-collected adults were available, Survey taxonomists narrowed the identification to the genus *Baris* and ruled out native species, suspecting that the invader might be *Baris lepidii* Germar, a small bluish weevil sometimes intercepted in U.S. ports of entry. When the U.S. Department of Agriculture specialists confirmed this identification, Illinois growers were faced with an exotic insect—previously known only on cruciferous crops in eastern and central Europe—that threatened the horseradish crop through direct root damage and as a potential contaminant in the prepared product.

Photo by Cathy Eastman, INHS Center for Economic Entomology

The crucifer weevil, Baris lepidii *Germar.*

The Tri-County Vegetable Growers Association asked the Survey to determine the incidence and severity of this weevil problem. With state support, a team of entomologists and horticulturists from the Section of Economic Entomology and the University of Illinois set out in August 1977 to determine the biology of the weevil and its pest management on horseradish. The urgent, sensitive nature of the project was soon evident when researchers learned that the first published report of the weevil's occurrence in the Western Hemisphere was being used by some processors to downgrade the price offered for purchase of Illinois horseradish, sight unseen.

Surveys of the growing area found infestations in over half the fields, indicating that the insect now known as the imported crucifer weevil undoubtedly had been present but undetected for several years. An exhaustive bibliography developed from available literature revealed only that *B. lepidii* was an occasional minor pest in its region of origin and provided little useful information to aid the Illinois studies.

Key to the success of the crucifer weevil project were the multidisciplinary-team approach, grower cooperation, and knowledge of horseradish production practices. Horseradish is produced from secondary roots ("sets") kept in cold storage or earthen pits for spring planting. Harvested late fall or the following spring, primary roots are sold for processing and sets are saved as planting stock. Root pieces remaining after harvest produce extensive patches of volunteer horseradish the following year in rotation crops of corn and soybean. Thus, horseradish is available to harbor the weevil year-round. Within that time frame, however, there were weak links that provided opportunities for population management once studies on the weevil's life history, temperature-related development, and best sampling methods were completed. Feeding injury by weevil adults was minimal; tunneling by larvae caused the greatest damage. The weevil was found to overwinter primarily as adults and eggs in unharvested or volunteer horseradish and as eggs in stored sets; few larvae survived the winter. Eggs laid in roots began development once temperatures exceeded 42°F. Because few adults have fully developed wings, dispersal was mainly by ground movement of adults from unharvested or volunteer horseradish and by planting of infested sets.

Destruction of eggs in sets and control of volunteer horseradish became the framework for the pest management program. Seasonal field surveys were conducted to alert growers to possible infestations. Evaluation of several methods indicated that soaking sets in 0.1% permethrin killed eggs without harming sets. The same product could be used as a foliar spray in August, if needed, to kill egg-laying adults. Discing fields after rotation crop harvest followed by glyphosate application four to six w later proved to b effective for cor volunteer horser Growers now ha environmentally friendly progra clean sets in cle ground—with w they could contr their own weevi lems.

B. lepidii tha is now viewed o an occasional m pest of horserad We will never k for sure how it c Illinois. Perhap was introduced i from out of state are unconfirmed ports of the wee two other growi gions. Neverthe the project provi the Survey with valuable opportu to spearhead a c erative effort wit growers, other re searchers, and ec tors to combat a welcome guest" keep its appetite mannerly contro

Cathy Eastman, Ce Economic Entomol with reference to th research and contri of these individuals the Illinois Natural Survey and Univers Illinois: Dan Sherr John Bouseman, Ric Foster, Bill Luckma Mike Burke, Chris L Bill Ruesink, Roscoe Randell, Herb Hope Clarence White, and Bonnie Irwin.

Status and Distribution of *Daphnia lumholtzi* Sars in Illinois

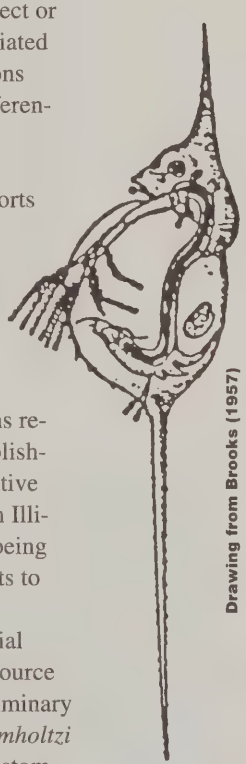
The exotic cladoceran, *Daphnia lumholtzi* Sars, was first discovered in North America in 1990 from a small lake in Texas. Since then, *D. lumholtzi* has spread extensively throughout the southeastern U.S. The native range of *D. lumholtzi* includes Australia, central Asia, and Africa. North American populations are believed to have originated from Africa since genetic studies revealed close similarities between these populations. Because of their inland distribution, it is unlikely that the species was introduced as a result of ballast-water discharge. Rather, *D. lumholtzi* appear to have 'hitchhiked' with the intentional introduction of other exotic species, such as Nile perch, *Lates niloticus*, and the cichlid, *Tilapia mossambica*. Unlike other exotic cladocerans (e.g., *Bythotrephes cederstroemi*), the expansion of *D. lumholtzi* in North America seems to have occurred in less time and over a larger geographic range. It has been postulated that their expansion may be due to transfer of ephippia via waterfowl, fishermen, or introduction of aquatic species and plants.

Successful establishment of *D. lumholtzi* has been linked to a variety of physical factors. In general, *D. lumholtzi* colonize in relatively small, unconnected bodies of water and then spread to other locations, a pattern opposite of that for *Bythotrephes* and *Dreissena*, which typically colonize large lakes and expand to smaller, connected water bodies. For example, *Bythotrephes* and *Dreissena* generally spread outwards from the Great Lakes, whereas *D. lumholtzi* has the potential to spread into the Great Lakes through smaller, connected water bodies, such as the Illinois River and Chicago area waterways. In the Southeast, *D. lumholtzi* are typically found in reservoirs greater than 225 ha, with mean August water temperatures greater than 25°C. Moreover, reservoirs containing *D. lumholtzi* typically have high conductivities and high concentrations of nitrite and nitrate.

The seasonal occurrence of *D. lumholtzi* differs from most native *Daphnia* in North America. *Daphnia lumholtzi* abundance typically peaks in late summer (August), when water temperatures exceed 25°C. Because their temporal distribution does not overlap with many common daphnids, the effect of *D. lumholtzi* on native cladoceran populations is unclear. Moreover, because their seasonal timing generally follows peaks in zooplanktivory by larval fishes, no effects have been observed in systems that have been studied. However, because of their large spines and helmets, predation rates on *D. lumholtzi* by planktivorous fishes is reduced compared to other *Daphnia*, implying that *D. lumholtzi* may affect foraging success of native fishes.

In Illinois, *D. lumholtzi* was first collected in July 1992 from Lake Springfield. Additional sampling in 1993 and 1994 revealed *D. lumholtzi* in 10 additional reservoirs: Carlyle Lake, Clinton Lake, Dutchman Lake, Lake Bloomington, Lake Decatur, Lake Kinkaid, Lake Shelbyville, Lake Taylorville, Rend Lake, and Sangchris Lake. They have also been collected in the Illinois River since 1995, but probably occurred in the river as far back as 1991. Recent studies have shown that the establishment of *D. lumholtzi* in Illinois has affected zooplankton composition and size structure. Since the establishment of *D. lumholtzi* in Lake Springfield, the zooplankton community has shifted from greater than 75% cladocerans to greater than 75% copepods. It has been postulated that these shifts could result from direct or indirect mechanisms associated with competitive interactions among zooplankton or differential predation pressure on daphnids.

At present, research efforts are focused on evaluating zooplankton communities in Illinois lakes with and without *D. lumholtzi*. Using time-series data from a variety of lakes, we are addressing questions related to effects of the establishment of *D. lumholtzi* on native zooplankton populations in Illinois. This information is being coupled to data on fish diets to help elucidate the role *D. lumholtzi* plays as a potential competitor or as a prey resource in Illinois reservoirs. Preliminary findings suggest that *D. lumholtzi* are a common diet item in stomachs of brook silversides, *Labidesthes sicculus*, but occur less frequently among other native zooplanktivorous fishes. Additional understanding of the potential effects of *D. lumholtzi* on Illinois ecosystems will assist in the development of management options.



Daphnia lumholtzi *Sars.*

Steven R. Chipps, David H. Wahl, Cynthia S. Kolar, Kaskaskia Biological Station, Center for Aquatic Ecology; and James A. Stoeckel, La Grange Reach LTRMP Field Station, Center for Aquatic Ecology.

The Rusty Crayfish in Illinois

Crayfishes, also known as crawfish or crawdads, are rapidly becoming one of the most destructive invaders of aquatic ecosystems in North America. When introduced into new habitats, non-native crayfish populations increase in size exponentially. Subsequently, the invaders will significantly reduce the size of native fish and amphibian populations by direct predation on their eggs. Non-native crayfishes can also affect fish populations by consuming the aquatic plants that juvenile fishes use for shelter. Perhaps the greatest effect of non-natives is felt by the native crayfishes. Through a variety of methods, invading crayfishes are extremely efficient at displacing natives species.

Unfortunately, one of the most destructive invaders, the rusty crayfish (*Orconectes rusticus*), has become firmly established in Illinois waters. The rusty crayfish was first collected in Illinois in 1973 from the Illinois River at Peoria and until 1985 was known from only nine locations (Fig. A). Since then the species has rapidly spread throughout the northern half of the state. A field study conducted by INHS biologists from June 1994 to October 1995 found the rusty crayfish at 39 sites in Illinois (Fig. B). Not only has the rusty crayfish expanded its range in Illinois, but it has done so at the expense of our native crayfishes. The rusty crayfish was the only crayfish found at 14 of the 39 sites collected in the 1994-1995 study. Prior to the introduction of the rusty crayfish, the native virile crayfish (*Orconectes virilis*) and northern clearwater crayfish (*Orconectes propinquus*) occurred commonly at most of these 14 sites.

The rusty crayfish is a large, aggressive species compared to other Illinois crayfishes and as such is able to force native species out of habitat that provides refuge from predation. Deprived of this habitat, species such as the virile and northern clearwater crayfishes are either consumed by fish or mammal predators or are forced to move to other areas. A second component influencing the success of the rusty crayfish is the type of habitat present. The rusty crayfish and most of Illinois' native species need shelter from predation. This shelter is usually in the form of rocks or boulders on the stream or lake bottom. Crayfishes will crawl under or between these rock and boulders for protection and it is this habitat that the rusty crayfish takes solitary control of. Rock or boulder substrate is an excellent predictor of where the rusty crayfish will most likely invade. This type of habitat occurs throughout much of the Kankakee, Vermilion, Fox, and lower Rock River drainages. The species is already known to occur in all of these river systems (Fig. B) and it is only a matter of time before it becomes more widespread in them.

Crayfishes are often used as fishing bait and as such unused individuals are often dumped into lakes and rivers at the end of the day. This practice has led to the establishment and rapid spread of the rusty crayfish in Illinois and other states. In recent years state legislation has been passed that bans the possession and use of the rusty crayfish as bait; however this might be a case of too little too late. The species is already well established in the northern half of the state and there is currently no known means to eradicate it. At a

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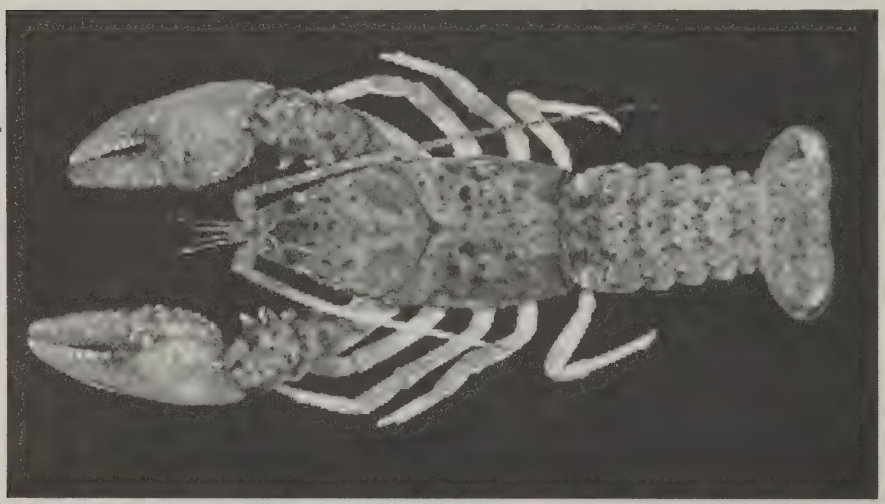

Photo by Chris Taylor and Kevin Cummings, INHS Center for Biodiversity

The rusty crayfish, Orconectes rusticus.

Rusty Crayfish

continued from previous page

minimum, strict enforcement of this legislation will help slow the spread of the rusty crayfish. Additional actions should include the continued education of anglers on the negative effects of rusty crayfish and the undesirability of dumping unused bait.

To prevent the introduction of additional non-native crayfish species into Illinois, new policies and legislation are needed. Wisconsin, a state that has seen a large portion of its native crayfish population eradicated by the rusty crayfish, has passed laws that ban the use of any live crayfish species as bait. These measures have had very little, if any, effect on the recreational fishing industry and serve as excellent means to prevent additional introductions. With two species of crayfishes known to occur only in Illinois and several others with small native ranges, it is obvious that the state would benefit greatly from similar legislation. If we are to protect our state's native crayfish diversity, we must take proactive steps to prevent introductions and not ignore what we have learned from the rusty crayfish.

Christopher A. Taylor, Center for Biodiversity

Fig. A. The Illinois range of the rusty crayfish in 1985.

Fig. B. The Illinois range of the rusty crayfish in 1996, with both solid circles and triangles indicating sites at which the rusty crayfish was collected.

Good Beetle, Bad Plant

Purple loosestrife (*Lythrum salicaria*) is a nonwoody perennial plant that came to North America from north-central Europe in the early 1800s, most likely in soil used for ballast of ships. Because it arrived without its natural mortality factors (herbivorous insects, plant diseases), loosestrife populations grew unchecked and it became an invasive weed that today occurs in wet areas throughout North America.

Several traits make the plant a formidable invader: hardiness, tolerance of a wide range of conditions, ability to exploit disturbed habitats, large size (over 8 ft. tall) and virtual freedom from insect pests and disease. Also, plants can produce over 2 million seeds the size of ground pepper, which can be transported by wind, water, or animals.

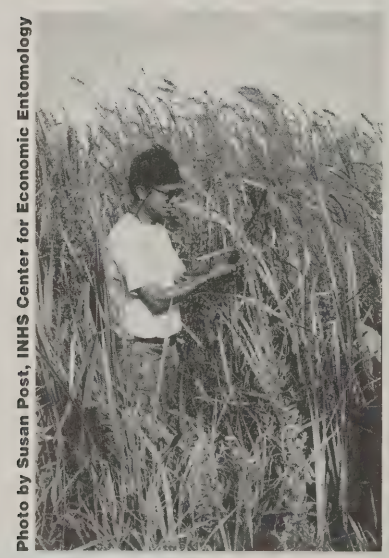

Photo by Susan Post, INHS Center for Economic Entomology

Fredy Cardona of INHS measures purple loosestrife at Hosah Prairie near Zion, Illinois.

Vast stands of loosestrife defy most control efforts, whether hand pulling, herbicides, burning, or flooding. That's why biological control has been welcomed—it's the only alternative in this case.

Five beetle species were considered most promising and host specific, and have been introduced into North America for biological control. Two species, *Galerucella calmariensis* and *G. pusilla,* have been released throughout the U.S. and Canada, and are now showing signs of success.

The Illinois loosestrife story illustrates how a biological control program can evolve to large-scale participation and success. In Illinois, the loosestrife biological control program began in 1994. Several county and state agencies purchased 7,000 adult *Galerucella* adults, which were released into field cages at seven sites in five counties in northern Illinois. INHS joined the group in 1995, and our part of the partnership has been to rear and distribute the biological control agents, and provide expertise about biological control. At INHS, large-scale production and distribution of *Galerucella* beetles has been ongoing since 1995. Each year, hundreds of purple loosestrife roots are dug and returned to the greenhouse, roots are potted, and plants are caged in tomato cages and covered with mesh bags. About 20-30 adult *Galerucella* are added and left to grow for a month until new adults emerge. Beetles are collected daily and shipped (or delivered) to collaborators throughout Illinois.

Since 1995, over 1 million *Galerucella* adults have been released at over 80 sites in Illinois. Collaborators also are rearing their own beetles on site, educating the public about loosestrife and other exotic plants—and releasing another 200,000-300,000 beetles.

Two Illinois sites are showing dramatically different impacts. At Hosah Prairie, adjacent to Illinois Beach State Park, a few hundred *Galerucella calmariensis* were released into field cages in 1994. Beginning in 1996, we sampled plants annually, classifying plants as either 1) damaged, and the plant failed to flower; 2) partially damaged, in which reduced flowering occurred; and 3) undamaged, in which full flowering occurred. In 1996, one-third of the 300 plants fell into each category, a sign of initial impact, as no damage occurred before the 1994 releases. By 1998, 42% were completely damaged, 47% partially damaged, and 11% had no damage. Beetle feeding has reduced loosestrife to a "background" plant, a splash of purple.

In Savanna, along the Mississippi River, came a different tale. In 1994, 1,000 *Galerucella* adults were released into field cages at three sites. In 1997, plants were heavily damaged at all three release sites, even 150 meters from a release point. Each site looked like a bull's-eye —a circle of brown, dead plants, 15-30 meters in diameter, surrounded by green, unflowering plants, which were surrounded by purple flowering plants. Beetles covered many plants, stripping every last vestige of green. And in the midst of the feeding frenzy, stood untouched, or just nibbled, plants of other species, showing us the beetles remained host specific. In 1998, the insects and their damage have moved well beyond the release points. Even more exciting, native plants are making a comeback.

It is too early to tell whether loosestrife is still "on the loose" or "on the run." Although we have made releases at 80 Illinois sites, many more need to be targeted. Many private sites where wetland mitigation projects are ongoing will be new targets. Initial impact seen at the two sites is not yet occurring elsewhere in the state. There will never be zero loosestrife because biological control will not eradicate exotic species. But, if Hosah Prairie is indicative, loosestrife may become a background splash of purple in the wetlands. Biological control, even if it puts loosestrife "on the run," is only a part of the solution. Other exotic species are waiting in the wings, ready to fill the void left by fewer loosestrife plants.

For more information, see the Survey's Loosestrife Web Site: http://www.inhs.uiuc.edu/cbd/loosestrife/bcpl.html

Robert N. Wiedenmann, Center for Economic Entomology; David J. Voegtlin, Center for Biodiversity

Bad Beetle Finds a Good Home

The Asian longhorned beetle (*Anoplophora glabripennis*) first gained notoriety in North America following its 1996 discovery in trees in Brooklyn and Amityville, New York. Much to the dismay of Illinois agricultural and forestry officials, during the summer of 1998 it was also detected in two Chicago neighborhoods and in an unincorporated area of DuPage County. Asian longhorned beetles are native to China, Korea, and Japan, where outbreaks frequently ravage stands of poplars, maples, and willows. Unseasoned wood cut from infested stands is commonly used to construct shipping crates and pallets. Larval stages of the beetle can readily survive in transoceanic shipments burrowed deep inside larger crating timbers. Inside the wood they transform into the pupa stage and later change into the adult stage. The adult beetle will then chew its way out of the wood leaving a large circular hole.

The Asian longhorned beetle poses an especially serious threat to our urban and forest trees. Its geographic range throughout Asia suggests that nearly all of North America, from the Great Lakes to southern Mexico, could be colonized. The host range of the Asian longhorned beetle encompasses the majority of trees commonly found lining neighborhood streets and populating our river-bottom forests. Maples, boxelder, willows, poplars, horsechestnut, locusts, elms, and mulberries are just a few of the many tree species attacked. Unlike most of our native longhorned beetles which develop in weakened or dead trees, the Asian longhorned beetle can develop in healthy trees.

Unfortunately, once a healthy tree is under attack, little can be done. Larvae can grow to two inches long and tunnel deep into the heartwood. Over time, repeated tunneling by larval infestations will weaken and kill the tree. The dime-sized exit holes left behind by emerging adults persist as irrefutable evidence of an infestation.

In both the New York and Illinois infestations, the current goal is eradication. Thus far, the infestations seem to be limited in scope and the adult beetles have a fairly short flight range. Nonetheless, eradication will take considerable time, effort, and resources. Living deep within infested trees, larvae are unreachable with conventional insecticide sprays. Repeated aerial applications of insecticides for adult suppression pose serious logistic and public health concerns in densely populated urban settings. Currently, quarantines are the first step in the eradication process. The purpose of a quarantine is to establish a legal boundary of infestation, which is based on survey results and the biology and behavior of the insect, to restrict the movement of beetles or infested materials into new, uninfested sites. Inspectors then painstakingly examine individual trees within the quarantine boundaries for evidence of egg laying or adult emergence. Any tree showing signs of infestation will be cut, chipped, and burned late in the fall when the larvae are inside the wood.

Eradication efforts in New York seem to have reduced the beetle's numbers, but at the cost of several million dollars and several thousand trees. In Illinois the battle with the Asian longhorned beetle has just begun; even if eradication is successful, it will likely be at least a five-year effort. As drastic and costly as these actions may seem, they hold the best hope of preventing the beetle's spread out of the urban environment into rural, state, and federal forests. To prevent repeated reintroductions of this insect, agricultural officials are seeking stricter regulations mandating kiln drying or fumigation of crating materials that originate from infested areas of Asia.

Charles Helm, Center for Economic Entomology; James Appleby, University of Illinois

Photo by James Appleby, University of Illinois

The Asian longhorned bettle, Anoplophora glabripennis.

Mosquito Marauders

Mosquitoes have effectively used man's transportation system to invade new habitats either man-made or natural. An example of a worldwide expansion of a mosquito is the yellow fever mosquito, *Aedes aegypti*. This mosquito was moved from its African home to the New World in sailing ships and into Asia via the dhow trade primarily into port cities along the Indian Ocean coast. This species spread into the United States from the Gulf Coast as far north as southern Illinois via river and ground transportation. The control of the yellow fever mosquito was critical for the U.S. to build and maintain the Panama Canal. In Illinois *Aedes aegypti* is still collected in and around Cairo and has been imported into Chicago almost every summer. Luckily this species is not adapted to freezing weather and has not been established in Illinois. Today, the rapid worldwide movement of man, animals, and domestic goods coupled with increasing urbanization into natural areas amplifies the risks of invasion of mosquitoes and mosquito-borne diseases.

Drawing by John Sherrod from INHS image archives

The Asian tiger mosquito, Aedes albopictus.

The invasion and rapid establishment of the Asian tiger mosquito, *Aedes albopictus*, highlighted the ever-increasing vulnerability of the United States to unwanted pests. Eggs of this mosquito were carried unknowingly in used tires from Japan to the port of Houston, Texas, and within two summer seasons spread north into Illinois. The immediate concern of both federal and state public health agencies focused on this mosquito's superior ability to transmit both exotic and local microbes that affect the health of man and animals. The Asian tiger mosquito can transmit 26 viruses that cause disease in man as well as the worm responsible for dog heartworm, a major problem in every county in Illinois for canines. This mosquito is a continuing challenge to agencies mandated to protect the public from nuisance and public health mosquito pests. The Asian tiger mosquito differs in both its ecology and behavior from other Illinois species because the immature stages prefer artificial containers (e.g., tires, cans, birdbaths, tree holes) and the adult is active during the day. It is definitely a mosquito adapted to exploit man-made habitats and its global dispersal is intimately linked with domestic goods, especially used tires.

The Asian tiger mosquito was not the only new mosquito in recent years to invade and expand in numbers in Illinois. Used tires were also used by the rockpool mosquito, *Aedes atropalpus*, another container-inhabiting mosquito to expand throughout the state. Recently, *Culiseta impatiens* was found for the first time in Illinois. Fortunately both of these species have not been associated with the transmission of pathogens affecting man or animals.

Natural catastrophes can also play an important role in expanding the distribution of mosquitoes. During the flood of 1993, *Culex tarsalis*, the primary transmitter of western equine and St. Louis encephalitis viruses in the western U.S., was collected in large numbers along the Mississippi and Illinois rivers. Before this natural event, this species was rarely found, and then only in very small isolated pockets. The expansion and establishment of this species could change the transmission cycle of St. Louis encephalitis virus in Illinois as well as provide for the emergence of western equine encephalitis east of the Mississippi River.

Mosquitoes, because of their blood-feeding behavior, are generally considered by both the lay population and scientific community as threats to either our public health or quality of life. However, the ecological roles that mosquitoes play both in aquatic and terrestrial environments are an important challenge for the Illinois Natural History Survey's Medical Entomology Program. This is especially important when a new species invades and becomes established in Illinois. Numerous questions need to be answered, such as Is this new species replacing a native, and if so how does this affect the intricacies and subtleties of the habitat? Mosquitoes in their aquatic stages, for example, help break down plant detritus and

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Marauders

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are sources of food for a variety of aquatic animals. In the adult stages mosquitoes help in pollination and are sources of food for a number of predators, and since mosquitoes transmit numerous pathogens that affect wild animals they could play a significant role in the process of natural regulation.

The invasion of exotic mosquitoes from foreign lands as well as the expansion of North American species into Illinois establishes the scientific need to address both the public health and ecological questions associated with this large insect group. Whenever a new species becomes established the natural history of the area will change. It is critical to understand and perhaps forecast whether the invader is beneficial or destructive. The basic biology of the invasive species must be evaluated in the context of its habitat or ecosystem before steps are taken toward managing populations or eradicating them. Invasive mosquito species must be evaluated in regards to their threat to public health and to domestic animals and wildlife, as well as short- and long-term ecological considerations.

Robert Novak, Center for Economic Entomology

The Beetle That Tried to Steal Christmas

The pine shoot beetle, *Tomicus piniperda*, is one of the more recent of the 360 or more exotic insects of woody plants now established in North America. A native of Europe, Asia, and North Africa, *T. piniperda* has a long history of interceptions at U.S. ports of entry on wood products such as crates, pallets, and dunnage. Established populations were first discovered in Ohio in 1992, but the fact that infestations were discovered in six surrounding states, including Illinois, within a month of the initial discovery suggests that this bark beetle had been in the U.S. for several years prior. Given its wide distribution within the Great Lakes region, eradication was not a consideration, but federal and state quarantines were imposed to restrict the movement of the pest and infested materials. Regulations associated with these quarantines have been especially difficult for Christmas tree growers who ship large numbers of pines to southern or western states.

Pine shoot beetle (PSB) has found the temperate climate and widespread occurrence of pine forests, Christmas tree plantations, and nurseries within the Great Lakes region highly suitable for colonization. Research has shown that PSB can use most, if not all, North American pines as hosts for breeding and shoot feeding, and since it is the first pine bark beetle to fly in spring, it has a competitive advantage over other native species of pine bark beetles. Adult PSB overwinter in the bark at the base of pine trees, but emerge in early spring and fly to recently killed or cut pine trees, logs, stumps, and pine slash. Eggs are laid beneath the bark of such brood material where larvae feed and develop. Progeny adults emerge in early summer and feed in tunnels in the shoots of live pines before moving to overwintering sites following the first hard frost. While high adult numbers can kill shoots and reduce tree growth, PSB populations have as yet had little impact on well-managed Christmas tree plantations.

In fact, in spite of its widespread distribution, PSB has not caused significant levels of damage to native forests anywhere within its new North American range. Nevertheless, existing quarantines have had major economic impacts on forest, nursery, and Christmas tree industries. Based on continuing research and the realization that PSB is here to stay, an integrated management program was developed to reduce beetle numbers in Christmas tree farms and reduce the overall burden of restrictive quarantine regulations. At certain stages of its life cycle, PSB is deemed particularly vulnerable to management actions. For instance, timely placement and destruction of trap logs can be effective in reducing adult beetle populations, good sanitation practices can eliminate brood material, and a single cover spray can control beetles during shoot feeding.

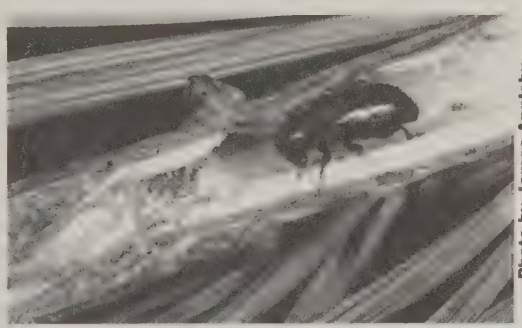

Photo by James Appleby, University of Illinois

The pine shoot beetle, Tomicus piniperda.

This integrated management concept has been formalized into a Pine Shoot Beetle Compliance Program. Growers who enroll in the program agree to a set of management guidelines and schedules along with scouting and strict record-keeping of their compliance with these management procedures. In return, if management practices and deadlines are fully met, growers in regulated areas can ship trees in the fall without restriction. Although this implies a certain element of risk of PSB presence on trees coming from compliance locations, preliminary data suggest the risk is minimal, if not less, than for trees grown under the more traditional regulations. This novel regulatory approach for an exotic pest appears both practical for growers and effective against the pest.

Charles Helm, Center for Economic Entomology; James Appleby, University of Illinois

Garlic Mustard: A Stinking Invasive Weed

Garlic mustard (*Alliaria petiolata*) is an exotic weed that was introduced to North America from Europe in the early 1800s. It occupies and spreads in forest floors and other natural areas, such as parks and natural preserves. Garlic mustard can be distinguished from other woodland plants by the characteristic odor of garlic that the plants give off when crushed. Garlic mustard is an invasive biennial herbaceous weed. The first-year plants consists of three to four rounded leaves rising to about four inches from the ground. The plants grow as a roseate in the summer and remain green the following winter. Because of the green

Photo by Weidong Chen, INHS Center for Biodiversity

First-year garlic mustard, Alliaria petiolata.

plants in winter, it is relatively easy to spot this pesky weed during the winter months. The second-year plants bloom early in May to early June and are about two feet tall when in bloom. They produce numerous white flowers with four separate petals. Fruits, consisting of slender capsules up to two inches long containing a single row of black ridged seeds, are developed in July. The ridged seed coat is believed to help its spread by attaching to animal fur and human clothes or by helping the seed float in water. Consequently, the usual distribution pattern of garlic mustard is along streams, edges of woods, and trails.

Numerous features of garlic mustard give the plant advantages in competing against our native flora. These features include monoecious reproduction (a single isolated plant can produce numerous seeds), tolerance to cold weather (an escape from competition of native plants), varied periods of seed dormancy (giving unsynchronized germination to escape detrimental environmental conditions), and offensive odor and chemicals within the plants protecting them from herbivores.

Garlic mustard invades woodland communities in the mid-western U.S. and adjacent Canada. It is now observed in at least 31 states and three provinces. Within individual communities garlic mustard population size may fluctuate widely from year to year, reflecting the biennial nature of this plant and the varied periods of seed dormancy. Across a region, the presence of garlic mustard consistently increases over time. In Illinois, garlic mustard is now widespread through the northern two-thirds of the state and occurs in state parks, natural preserves, and other natural areas in at least 41 counties. Garlic mustard is so aggressive that monospecies stands have become established in many natural areas and now pose a threat to the natural quality of Illinois forests and significantly reduce biodiversity of our native plant communities. It is considered one of the critical exotic weeds in Illinois natural areas.

The rapid spread of garlic mustard threatens the floristic structure, particularly the herbaceous layer. Current control measures of garlic mustard are mechanical cutting, prescribed fire, and application of glyphosate-containing herbicides. The most effective control of garlic mustard at initial or minor infestations is by hand pulling or by mechanic cutting before flowering begins. If viable seeds are already set in the pulled or cut plants, they should be removed from infested areas preferably to compost piles. Prescribed burning in the fall or early spring is applicable to large infestations. Plants in their green vegetative state cannot tolerate fire and, therefore, they are likely killed during burning. Fall burning can take advantage of the new leaf fall as fuel, but early spring burning can

Continued on next page

Garlic Mustard

continued from previous page

minimize fire injury to spring wildflowers. Due to the biennial nature of garlic mustard and the varied dormancy of its seeds, several years of burning may be required and should be followed with hand pulling and mechanic cutting in order to provide effective control. The control measures can also be combined with application of the glyphosate-containing herbicides. The herbicide can be applied in the fall and early spring to minimize injury to native flora when most native plants are dormant and garlic mustard is green and vulnerable.

Research efforts in the biological control of garlic mustard have been under way using fungal pathogens to control this invasive weed so that this biocontrol measure can be incorporated into integrated management practices. Fungi are notorious plant pathogens, and some effective control measures of weeds with fungal pathogens have been achieved in other crop systems. Since 1994, research conducted at the Illinois Natural History Survey has aimed at developing biological control measures that are compatible with current management practices. We have made extensive efforts in collecting diseased garlic mustard from central and northern Illinois. From those collected garlic mustard specimens we have isolated and identified a number of fungal pathogens. Those identified pathogens include *Alternaria* spp., *Fusarium oxysporum*, *Fusarium solani*, *Phoma* spp., and *Sclerotinia sclertiorum*. These are known plant pathogens. Greenhouse tests showed that some of the fungal isolates are severely pathogenic to garlic mustard. For example, in greenhouse tests the isolate GM-7, *Fusarium solani*, caused significant reduction in the number of live plants. Seventy-five percent of the plants were killed three weeks after transplanting compared to no plants killed in the control treatment (Fig. 1). It caused root rot and basal stem rot of garlic mustard. This pathogen is not pathogenic to a *Viola* sp., a native plant that frequently grows with garlic mustard. The effectiveness of the pathogen against garlic mustard in natural settings needs to be more extensively tested.

Future research on biological control of garlic mustard should focus on the requirements of disease development, such as the effective ranges of temperature and humidity, and the most susceptible stage of the host to the pathogens. Garlic mustard has spread rapidly over recent years and this stinking weed will not go away by itself. There are no quick solutions available for this invasive weed. To preserve our native woodland herbaceous flora and the wildlife dependent upon it, concerted efforts are required to work on garlic mustard to discover an applicable and effective integrated approach in order to suppress its rapid spread.

Acknowledgments: Information about the current control practices is based on studies by Nuzzo (1991, 1993). The research on biological control of garlic mustard is supported by the Illinois Department of Natural Resources and by the Research Board of the University of Illinois at Urbana-Champaign.

Weidong Chen, Center for Biodiversity

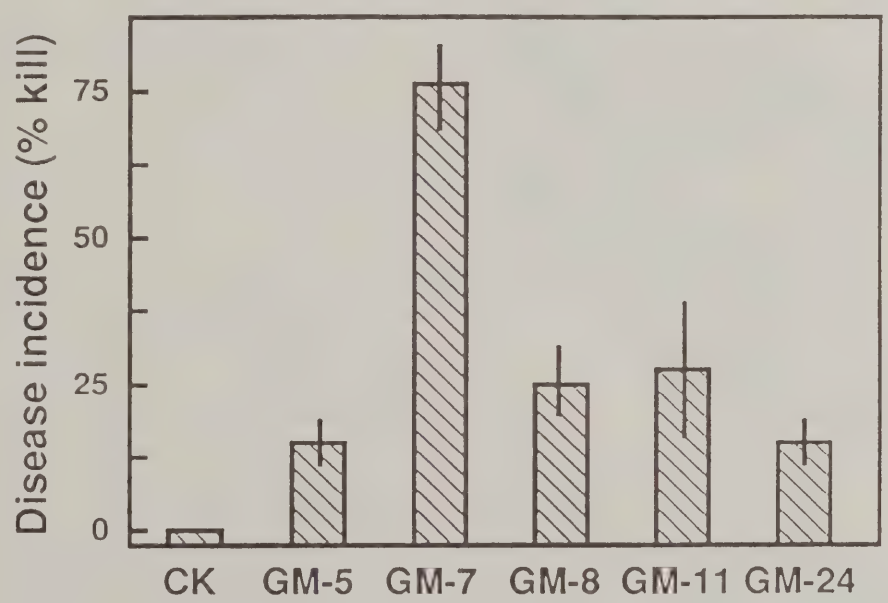

Fig. 1. Disease incidence (% kill) of garlic mustard (*Alliaria petiolata*) three weeks after inoculation with spore suspensions of five fungal isolates. Plants treated with sterile distilled water were used as control (CK). Vertical bars represent 95% confident intervals (n=6). The isolate GM-7 killed more than 75% of the plants and showed promise to be a candidate for biocontrol of this pest plant. The isolate GM-7 was identified as *Fusarium solani* and was obtained from a diseased plant found in the Manito Prairie Natural Preserve, Tazewell County, Illinois.

What is a Pest?

Susan Post and Carolyn Nixon

OBJECTIVE: to develop a definition for the word "pest"
SKILLS/PROCESSES: generalization, classification, application, value judgments
VOCABULARY: pest, pesticide
PROCEDURE:

1. Divide a section of the chalkboard into three columns. Label the column to your left "Pests"; label the center column "Reasons"; leave the third column unlabeled at this time. Ask the class to name insects that are pests; list these in the column to the left. As each insect pest is named, ask why we consider it to be a pest. Probe for as many reasons as students can provide, and encourage them to be specific. Write these reasons in the center column.
2. Ask for the names of animals other than insects that are pests. Add these along with specific reasons to the columns on the chalkboard.
3. Ask for the names of plants that are pests and add these, along with justifications, to the lists on the chalkboard.
4. Review with the class the column of reasons and ask them to define general categories into which those reasons might be sorted. These categories will depend upon the list of reasons, but they will probably include the following four in one version or another:
    a. Carry disease
    b. Eat our food or damage the plants or animals we grow
    c. Damage our possessions
    d. Cause inconvenience

List these general categories in the third column on the chalkboard, and head the column "Characteristics of Pests."

5. Working together, assign each reason in the center column to one of the characteristics in the column on the right by drawing an arrow from left to right. The abbreviated example on the next page indicates the kinds of responses you can expect.
6. Ask students to name some insects that they do not consider to be pests and to explain why these are not pests. Ladybugs, dragonflies, butterflies, and honeybees are likely to be named. Repeat for animals other than insects and for plants. Be sure to ask students to explain why they do not consider these to be pests.
7. Ask each student to define a pest on a slip of paper. You may collect these or ask for volunteers to read their definitions. In either case, decide on a class definition of a pest. Whatever the particulars of that definition, be sure students realize that organisms are pests only when they interfere with us in some manner. A mouse in the house is a pest, but mice in the meadows are not. A flour beetle in the pantry is a pest, but beetles outside may not be.
8. Which pests listed on the chalkboard are pests sometimes and not at other times? Under what circumstances are they pests?
9. Conclude the activity by discussing briefly the ethics of pest control and pesticides. When should pesticides be used? How much "damage" is acceptable before we resort to the use of poisons?

An example of how your activity may look:

Pests	Reasons	Characteristics of Pests
termites	eat houses eat sandboxes eat barns and sheds eat fences	a. carry disease
mosquitoes	bite us	b. eat our food or damage the plants or animals we grow
flies	land on our food spread disease bite us make spots on the wallpaper annoy our pets	
pigeons	make a mess in the city carry disease	
rats	spread disease invade our homes eat our food get into our garbage get into our sewers	c. damage our possessions
squirrels	steal food we put out for birds dig holes in our lawns get into our attics	d. cause inconvenience
dandelions	crowd out the grass spoil the appearance of lawns	
poison ivy	gives us rashes spreads into our yards	

EVALUATION

Give students five minutes to write an answer to this question: When is a pest not a pest? Request that their answers include reference to three organisms commonly considered to be pests.

Activity excerpted from Illinois Natural History Survey Special Publication 9—*Legacy of a Pest* (a curriculum detailing the environmental problems associated with an introduced organism, the gypsy moth). To obtain a copy of this publication, contact the Illinois Natural History Survey Distribution Office at 217-333-6880.

Biodiversity, Wetlands, and Biological Control: Information and Activities for Young Scientists—Purple Loosestrife: A Case Study is a new curriculum developed to provide middle school students with an appreciation of the complexity of natural wetlands, the threats from exotic invaders, and the potential of biological control as a management tool. This curriculum is currently only available through a workshop. Please contact Dave Voegtlin at 217-244-2152 for more information.

ILLINOIS
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Under Siege

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al, to study their impact both on our environment and economy, and to develop strategies to prevent introductions of new invasive species and control invaders that have already arrived, or at least limit their spread and harmful effects. Control methods for invasive species should be designed to have maximum effectiveness against targeted organisms but minimum negative impact on native species and their habitats. Integrated pest management is a comprehensive strategy used by INHS scientists that can include biological control as well as carefully timed and targeted chemical control. These methods are described in further detail in other articles in this newsletter.

Interestingly, the news about invasive species is not all bad. There are a few success stories that have resulted from cooperative efforts of INHS researchers with govermental agencies and commercial and private interests that are affected most by invasive species. (See articles on crucifer weevil, pine stem borer, and purple loosestrife for some good news.) Once we know the the basic ecology of an invasive organism, we can develop long-term control measures that can be both environmentally friendly and economically sound. The monitoring activities for invasive species at INHS as well our studies on the life histories of invaders and development of contro methods will continue. We may never stop unwanted invasions bu there is a realistic potential for us to keep invasions under control when they occur.

Richard Sparks, Director of the Water Resources Center at the University of Illinois

ILLINOIS NATURAL HISTORY SURVEY

Reports

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February 1999
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INSIDE

Franklin's Ground Squirrel: An Increasingly Rare Prairie Mammal

While thirteen-lined ground squirrels are a common sight on roadsides, golf courses, cemeteries, and lawns in northern and central Illinois, the other ground squirrel that lives in Illinois is less familiar. Franklin's ground squirrel, also called the gray gopher or whistle pig (because of its vocalizations), is primarily an inhabitant of the northern Great Plains from Alberta and Saskatchewan to Kansas and Missouri, but its range extends eastward through northern and central Illinois into northwestern Indiana. It is considered a characteristic species of tallgrass and mid-grass prairie. Franklin's ground squirrels occupy not only the open prairie, but also woodland edges, forest openings, thickets, and marsh and bog borders. Their most important habitat requirement is a tall, dense cover of grasses, forbs, shrubs, and even small trees; they avoid the short grass of closely grazed pastures or mowed areas. In regions of intensive agriculture suitable habitat remains in fencerows, old fields, roadsides (if not mowed frequently), cemetery prairies, ditch banks, and railroad rights-of-way. Railroad embankments are considered especially important because few other places may have dense, undisturbed vegetation.

Photo from INHS image archives

Franklin's Ground Squirrel, *Spermophilus franklinii.*

As true hibernators Franklin's ground squirrels are active less than half the year. They typically emerge from hibernation during April. Breeding occurs shortly thereafter and females give birth to a single litter (usually six to nine pups) from late May to mid-June. Franklin's ground squirrels are strictly diurnal and may be the most carnivorous of the ground squirrels. Their diet includes green plants, seeds, fruit, insects, amphibians, bird eggs, young birds and mammals, and carrion. They can be significant predators of duck eggs in the Prairie Pothole region and also cause some crop damage. Adults enter hibernation as early as July, but young squirrels have been collected in Illinois as late as mid-November. Overall, this species may spend less than 10% of its life aboveground.

Prior to European settlement, prairie covered 60% of Illinois, but more than 99% of our native prairie has been lost to agriculture and urbanization. Although there are historical records of Franklin's ground squirrel from numerous locations in northern and central Illinois, recent information about its distribution and abundance is limited. In 1986 University of Wisconsin researchers surveyed Illinois wildlife managers, natural heritage biologists, and naturalists; they reported sightings from 22 locations in 16 counties. Many biologists have speculated that Franklin's ground squirrel is becoming increasingly uncommon in the eastern portion of its range

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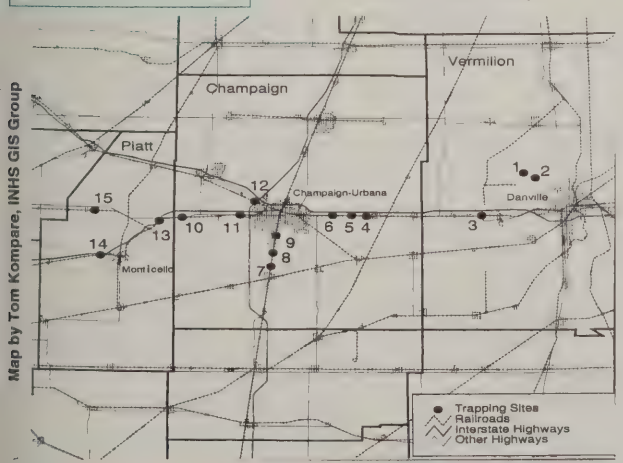

Map by Tom Kompare, INHS GIS Group

Locations of traps set to capture Franklin's ground squirrels.

Forest Regeneration and Understory Dynamics Following the 1993 Flood on the Illinois River

Floodplain forests along major rivers are very dynamic systems whose plant species are strongly adapted to disturbance. Tree regeneration in these forests mainly occurs when major floods kill large percentages of the existing stands. A rare opportunity to study floodplain forest tree regeneration and understory dynamics presented itself in 1993 when a devastating flood occurred on the Illinois River.

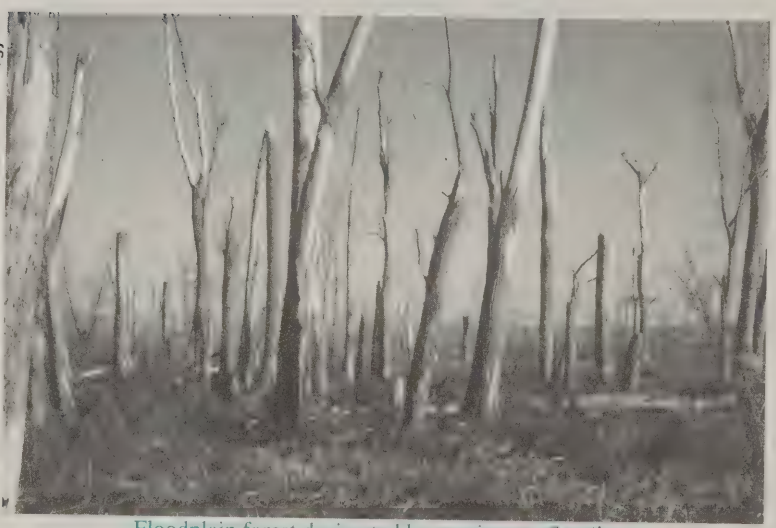

Photo by Allen Plocher, INHS Center for Wildlife Ecology

Floodplain forest decimated by continuous flooding.

Within the Sanganois Wildlife Management Area near Beardstown, Illinois, four stands were identified in which virtually all trees had been killed. These stands were underwater continuously for six to eight months, including one entire growing season. In 1995, in the second growing season after floodwaters receded, I began to study changes in species composition of tree regeneration over time and compare the species composition of the new stands of trees to that of the forests that had died. I also wanted to study species changes in the understories as the new trees grew larger and produced more shade. Recent research has shown that man-made alterations to river hydrology in the Midwest over the last 60 or 70 years has caused floodplains to flood much more often during the growing season than they did under natural conditions. This change has resulted in a change in species composition in the associated floodplain forests. A large body of research has shown that, after forests are cleared, the understories are first dominated by aggressive, fast-growing, shade-intolerant herbaceous and shrub species. Over time, these are replaced by more conservative, slower-growing, shade-tolerant species typically found under dense forest canopies.

In each of the four stands, permanent transects were established and the vegetation was quantitatively sampled every year, starting in 1995. Bark and branching patterns of the dead trees were used to make species determinations. Tree mortality in the four stands varied from 92% to 100%. Average tree diameters ranged from 8 to 12 inches and each site had a few trees 20 to 30 inches in diameter. Tree densities averaged 219 stems per acre. Although other studies have shown that smaller trees are more likely to be killed by flooding than large trees, the average diameter of live and dead trees in this study was virtually identical. It seems that when conditions are so extreme that tree mortality exceeds 90%, difference in size becomes less important.

In all four stands, the overstories were strongly dominated by silver maple and green ash (60%, 30%), with much lower numbers of cottonwood, black willow, and elm. In each stand, a dense cover of herbaceous vegetation over a meter tall has developed. Panicled aster is dominant, along with cocklebur, bur cucumber, beggar's ticks and white morning glory. Although panicled aster is common in floodplain forests, all of these are early successional, pioneer species. Therefore, after five years, a shift to lower, more shade-tolerant forest herbs has not yet occurred. However, at each site a new stand of shrub/sapling stage trees has developed. At sites 1, 3, and 4, tree species four to eight feet tall now occur at a density of 810 stems per acre. Site 2, which appears to be considerably wetter than the other sites, has a much lower density (255 stems per acre) of shrub/sapling stage trees.

In 1995, the second growing season after the flood, tree regeneration was present in the seedling stage. As one would expect, at all sites the seedlings were

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Forest

continued from previous page

dominated by silver maple and green ash, the same species that dominated the overstory. However, by 1998, a drastic change in tree regeneration species composition had occurred. The dominant species are now black willow, cottonwood, and green ash (30%, 20%, 15%). The silver maple, dominant in 1995, has almost disappeared in all but site 3, where it occurs at a much reduced level. It appears that the new forests developing at these sites along the Illinois River will indeed have different species compositions than forests that became established here 50 or 60 years ago. Black willow, and possibly cottonwood, are considered to be more tolerant of wetter conditions than silver maple. Green ash, on the other hand, is thought to be similar in flood tolerance to silver maple. It is not clear why conditions at these sites were not suitable for silver maple but acceptable for green ash.

Research will continue at these sites. As the young trees begin to produce increasing shade over the next few years, it is hoped that changes will occur in the herbaceous understory species composition. Elevations will be determined for each site in order to quantify differences in hydrology. Vegetation dynamics between sites and between years will be analyzed statistically in order to more accurately look for patterns.

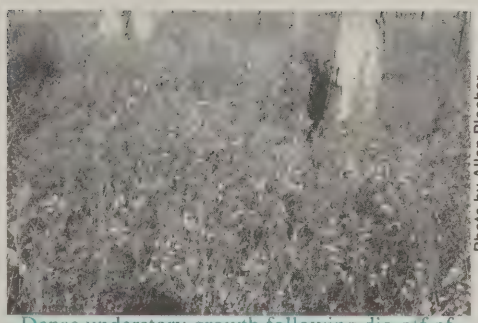

Photo by Allen Plocher, INHS Center for Wildlife Ecology

Dense understory growth following die-off of floodplain forest.

Allen Plocher, Center for Wildlife Ecology

Development and Application of a Gambusia Bioenergetic Model

Mosquitofish, *Gambusia affinis*, are one of the most widely introduced freshwater fish in the world. *Gambusia's* reputation as a mosquito control agent has been the impetus for large-scale introductions of the species. Their ability to tolerate a broad range of temperatures, salinities, and dissolved oxygen concentrations, combined with their prolific reproductive potential, enable mosquitofish to become easily established in non-native habitats. Establishment of *Gambusia* populations in non-native habitats, however, has also resulted in negative impacts for many native cyprinids. To facilitate management questions regarding appropriate densities and habitats to introduce mosquitofish as well as understand the ecological role of these fishes, better knowledge of their feeding requirements and growth dynamics is needed.

Development and corroboration of a *Gambusia* bioenergetic model is a first step to providing a tool that could be used to study resource demand and growth dynamics in mosquitofish. Based on laws of thermodynamics, bioenergetic models represent mass balance equations that link energy intake to energy expenditures. In generalized form, bioenergetic models can be expressed as,

consumption = (metabolism) + (wastes) + (growth).

Each of these physiological processes can be independently measured in the laboratory and is generally expressed as a function of body size and water temperature. External variables, such as water temperature, diet, and fish growth rate, are then measured in the field and used as input to the model to estimate food consumption.

Using published information and results from laboratory studies conducted at the INHS Sam Parr Biological Station, we are developing and testing a bioenergetic model for *Gambusia*. In a series of feeding trials, we found that *Gambusia* feeding rates were highest at water temperatures ranging from 30 to 35°C. At these temperatures, specific consumption rate by *Gambusia* was relatively high and ranged from 34% to 175% (g dry wt prey/g^{-1} dry wt *Gambusia* d^{-1}) for *Gambusia*-fed chironomids. We are using these data and information on *Gambusia* metabolic rates in the bioenergetic model to estimate seasonal energy requirements of mosquitofish. In addition, we are evaluating model performance using independently derived field estimates of *Gambusia* feeding rates. We are quantifying seasonal growth and food consumption of a local *Gambusia* population and comparing field-derived consumption estimates to those predicted by the bioenergetic model. We anticipate that development and corroboration of a *Gambusia* bioenergetic model will provide a useful tool for addressing a variety of ecological and management questions regarding the common mosquitofish.

The mosquitofish, *Gambusia affinis*.

Photo by Steve Chipps, INHS Center for Aquatic Ecology

Steven R. Chipps, Michelle A. Bouchard, and David H. Wahl, Center for Aquatic Ecology

Monitoring the Spread of Western Corn Rootworm Beetles Infesting Illinois Soybean Fields

Historically, adult western corn rootworm beetles (WCR, *Diabrotica virgifera virgifera*) have exhibited a strong fidelity to cornfields for both feeding and egg-laying. Because WCR larvae can survive only on corn roots (and those of a few other grasses), growing a non-host, like soybeans, where WCR eggs were laid the year before meant WCR larvae emerged where they had no food source and quickly died. Corn planted where soybeans were produced the previous year could be grown without use of a WCR-targeted soil insecticide because WCR did not lay eggs outside of corn.

Around 1986; a WCR strain appeared in several cornfields in Ford County, Illinois, that could circumvent crop rotation by laying some eggs in the non-host crop rotated with corn. By 1995, serious economic damage to corn rotated with soybeans was documented in nine east-central Illinois counties ("WCR problem area"). At present, WCR with behavioral resistance to crop rotation have spread to other areas in Illinois, Indiana, Ohio, and Michigan. Growers in and around the WCR problem area can no longer rely on crop rotation to manage rootworms in corn grown after soybeans (or other crops), and must use soil insecticides costing approximately $15 per acre to control WCR in first-year corn.

As part of our continuing work to understand this problem and its spread, each year we conduct a sweep sample survey of WCR abundance in Illinois soybean fields. During July and August of 1998, we used 15-inch diameter sweep nets to sample WCR populations in weed-free soybean fields that were adjacent to cornfields. We surveyed 140 locations in 44 counties and two fields were sampled at most locations. A total of 271 samples (100 sweeps/sample) were collected and preserved on dry ice. A similar procedure was followed in 1997, when insects were collected in corn and soybeans in 29 counties.

These data suggest there was no significant westward expansion of the WCR problem in 1998.

In 1997, WCR populations were extremely high in soybeans throughout east-central Illinois. Where WCR were particularly abundant, it was not unusual for an individual 100-sweep sample in soybeans to contain several hundred WCR adults (at one site in Vermillion County, Indiana, Purdue scientists reported 1,081 WCR collected in 100 sweeps!). In addition to being very abundant in soybean fields, dissection of female WCR from the 1997 samples revealed that a greater proportion of those from problem area soybean fields were carrying mature eggs than females in nonproblem area soybeans or females in corn from any county.

Compared to 1997, the average abundance of WCR in Illinois soybeans appears to have declined by almost tenfold in 1998 (Figure 1). WCR abundance in soybeans declined in all but one of the counties sampled in both 1997 and 1998 (Moultrie County). We believe early summer rains drowned many WCR before they became established on corn roots. Even with a much lower population density statewide, WCR were still significantly more abundant in the region previously identified as being at highest risk for egg-laying by WCR in soybeans (WCR problem area) than in areas north, south, or west of that region. WCR were not detected in 14 of the sampled counties.

These data suggest there was no significant westward expansion of the WCR problem in 1998. WCR continue to be present at low or undetectable levels in soybean fields west of the Illinois River and south of Interstate 70. These data should not be interpreted as a blanket forecast for any location in a county. Pockets of higher abundance exist in regions with only moderate county averages. WCR management decisions for 1999 should be based on local observations and use of scouting procedures developed for WCR in soybean fields.

Joseph L. Spencer, Eli Levine, and David Onstad, Center for Economic Entomology; Scott A. Isard, Department of Geography, University of Illinois; and Mark Joselyn, Center for Wildlife Ecology.

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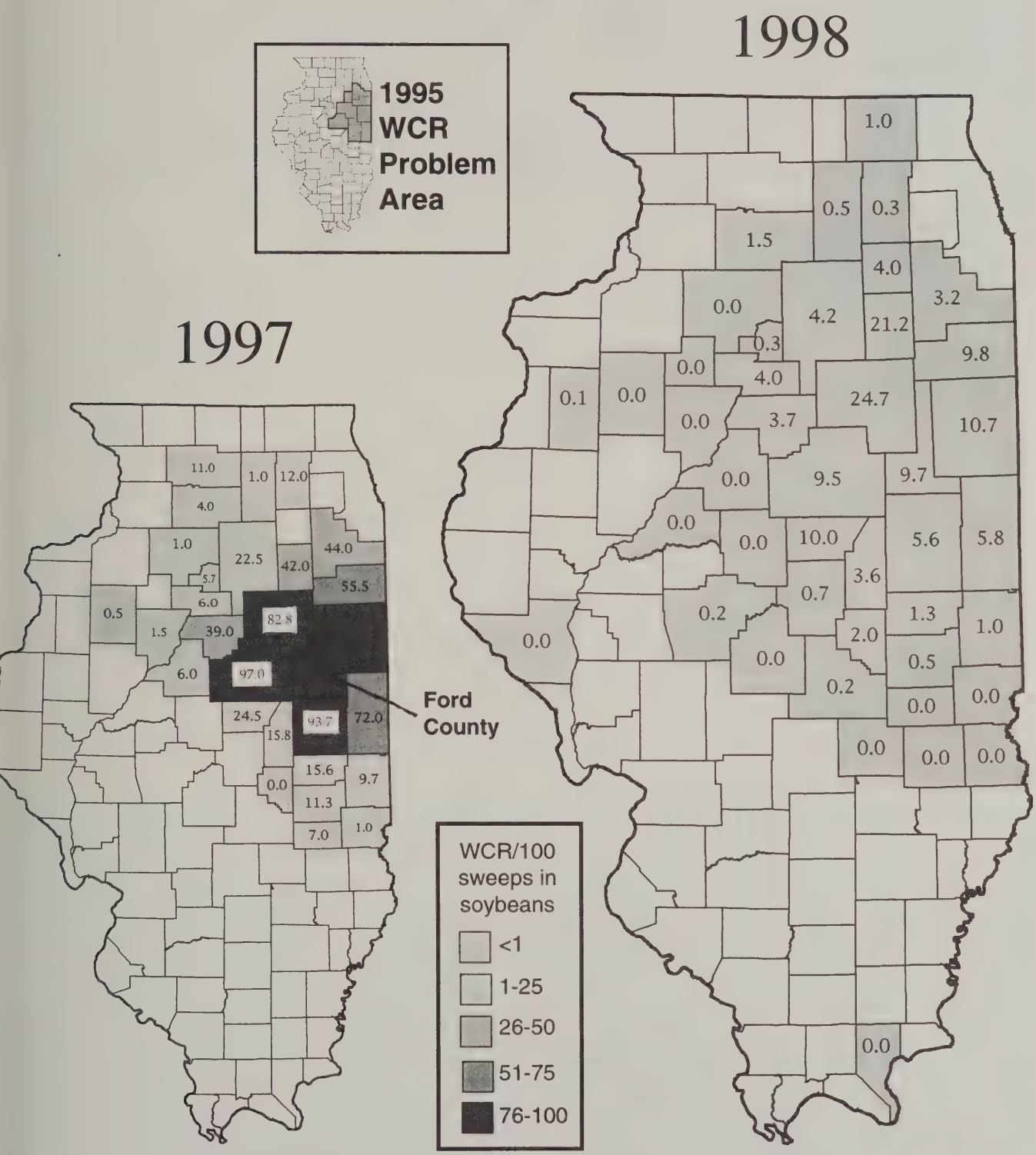
Figure 1


1998
1995 WCR Problem Area
1997
Ford County
WCR/100 sweeps in soybeans
<1
1-25
26-50
51-75
76-100

Species Spotlight

Short-tailed Shrew

Susan Post, Joyce Hofmann, Charles Hofmann

Photo from INHS image archives

The northern short-tailed shrew, *Blarina brevicauda*.

While Shakespeare's farcical portrayal of the ill-tempered Kate in *Taming of the Shrew* may raise a few politically correct eyebrows today, a firsthand encounter with the tiny but ferocious short-tailed shrew leaves little doubt why the term "shrew" is applicable to someone with a nasty disposition. Even old rough-and-tumble Teddy Roosevelt was impressed with the aggressive demeanor of his pet shrew, writing "certainly a more bloodthirsty animal of its size I never saw."

One of the most ubiquitous and abundant mammals to inhabit Illinois and Indiana, the short-tailed shrew is seldom seen in its natural habitat and is most likely to be encountered when it becomes "something the cat dragged in." If they are seen, shrews are often mistaken for mice or voles because of their small size, but they are not rodents, belonging to a separate mammalian order, the Insectivora. Weighing only an ounce and stretching a mere five inches, the short-tailed shrew is still the largest shrew species found in our area. Its cylindrical body is covered with short, velvety gray to black fur; but the long, pointed, flexible nose, tiny beady eyes, and small ears hidden in its thick fur give it a somewhat demonic appearance. Add to this a distinctive, but mysterious, red or brown pigmentation of their teeth and it's no wonder the shrew has historically received more than its share of bad press.

Just about any habitat can sustain a population of shrews: upland or bottomland forests, grasslands, weedy fields, wetlands, and occasionally even buildings. Population densities most certainly vary among these habitats, but can reach 80 per acre in moist forests with a thick layer of leaf litter and numerous logs. Shrews are active year-round and spend most of their time in underground burrows or scurrying through grassy tunnels in open fields or through leaf litter on forest floors. Because of poor vision, they rely on their sensitive snouts and abundance of whiskers to navigate; adding to their mystique they also use a form of echolocation, more often associated with bats and dolphins.

Female shrews construct a bulky, oval-shaped nest of partly shredded leaves and grasses beneath a fallen log or stump. The young are born in the nest from early spring until late September with usually four to six per litter. Three to four litters are produced per year. When born the shrews are naked and their eyes and ears are closed. They are the size of a honeybee, but within one month they are half grown.

Shrews are without a doubt one of the most ferocious mammalian predators—as one naturalist put it, "the tigers of the small animal world." But thankfully, due to their small size, their prey consists largely of earthworms, snails, slugs, insects, and other invertebrates. Occasionally they will resort to small amounts of plant material, but the real "beasts" are more likely to take on other small rodents, salamanders, and snakes. To further add to their charm, shrews are one of the few venomous mammals in the world. Their saliva contains a powerful toxin that can cause a painful reaction in some humans, but is more useful in immobilizing its prey. The immobilized prey can be cached alive to serve as a larder of food that will remain fresh for several days.

Some shrews do end up on the wrong end of the food chain. Owls, hawks, snakes, and weasels are known to feed on shrews, but other predators make the kill, then leave them uneaten—like those gifts the cat sometimes leaves on the doorstep. Though the shrew paid the ultimate price, it gets the last laugh—a foul, musky odor produced by scent glands on its flanks gives it a taste as bad as its personality.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Shrew Mathematics

Objective: to understand that shrews are important members of the food web in any yard, field, or woods in Illinois, and to understand what it means when it is said shrews have a high metabolism.

Materials: Multiple copies of "Shrew Mathematics," calendars, calculators.

Comments: Adult short-tailed shrews range in weight from 11 grams to 27 grams. Males tend to be slightly larger than the females. Shrews have been shown to be important in controlling outbreaks of insects. When calculating how many quarter-pound hamburgers a person would have to eat, include only the weight of the burger, not the bun or other ingredients.

Procedure: Read the questions on the following page and calculate the answers. You will need to know the number of days in each month, and each student should know his or her own weight.

Answers

1. A shrew weighing 19 grams would need to eat 28.5 grams of insects. It would take 9 1/2 grasshoppers each weighing 3 grams to weigh 28.5 grams. Since a shrew cannot kill half a grasshopper, it will kill and eat 10 grasshoppers a day.

2. If 10 grasshoppers are eaten in a day, 70 can be eaten in a week.

3. There are 122 days in a growing season. One shrew can eat 10 grasshoppers a day, so it can eat 1,222 grasshoppers in a growing season. Three shrews can eat 3,666 grasshoppers.

4. For each pound of body weight, you would need to eat 6 hamburgers. For each 10 pounds of body weight, you would eat 60 burgers. For each 50 pounds you would need to eat 300 burgers. A 100-pound person would need to eat 600 quarter-pound hamburgers a day. Just think how much ice cream you could eat!

Shrew Mathematics

Carolyn Nixon

Shrew Mathematics

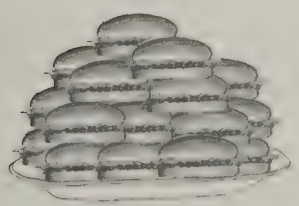
The short-tailed shrew is a ravenous predator that is found throughout Illinois. Although it is seldom seen, it is common. There can be as many as 50 shrews living on one acre of land. In woodlands in Illinois, there are commonly 10 to 20 shrews per acre. They are less common in grassy areas. Few animals are as hungry as a shrew. It must eat 1 1/2 times its own body weight in insects and other small animals in a single day. Solve the following problems so you can picture how much a shrew really eats.

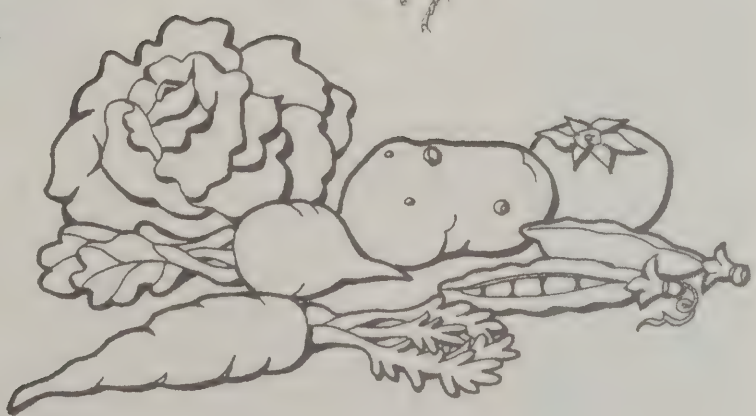
1. The short-tailed shrew must eat 1 1/2 times its own body weight in insects each day. If a shrew weighs 19 grams and a grasshopper weighs 3 grams, how many grasshoppers must a shrew kill and eat in one day? (Count each grasshopper killed in a day. If only part of a grasshopper needs to be eaten, count the whole grasshopper. For instance, 2 1/2 grasshoppers needed in a day would be three grasshoppers killed and eaten).

2. How many grasshoppers must it eat in one week?

3. If three shrews live in your garden, how many grasshoppers can they eat in one growing season? (Consider June, July, August, and September as the growing season).

4. If you had to eat as much as a shrew (1 1/2 times your body weight), how many quarter pound hamburgers would you have to eat in one day?





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Ground Squirrel

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and its distribution in Indiana apparently has shrunk. Accordingly, Franklin's ground squirrel is listed as an endangered species in Indiana and a species of special concern in Wisconsin.

To assess the status of Franklin's ground squirrel in east-central Illinois I conducted a live-trapping survey during spring 1998. The survey focused on Champaign County, the Illinois county in which the largest number of specimens has been collected. Traps were placed at nine sites in Champaign County and three sites each in adjacent Vermilion and Piatt counties. Eleven of the sites were located near historical records for this species. Two sites were in grasslands at Kennekuk County Park (Vermilion County); the others were along abandoned or active railroad lines. All sites had a dense cover of grass, forbs, and shrubs. Traps were baited with cracked corn, carrot, and sliced meat, and each site was trapped for three consecutive days. Only one Franklin's ground squirrel was captured during 1,032 trap-days, an adult male trapped along an abandoned railroad embankment east of Urbana. This supports the perception that Franklin's ground squirrel has become rare in Illinois. It also demonstrates the importance of preserving or restoring vegetation along abandoned railroad corridors for wildlife habitat. Surveys in other parts of Illinois and additional habitats (perhaps interstate highway rights-of-way) would shed more light on the conservation needs of this prairie species.

Joyce E. Hofmann, Center for Biodiversity

Photo by Joyce Hofmann, INHS Center for Biodiversity

Abandoned railroad right-of-way east of Urbana where a single ground squirrel was captured.

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OIS NATURAL HISTORY SURVEY

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INSIDE

Collections: The Foundation for Our Research and Education Programs

From its origins in 1858 to today, the Illinois Natural History Survey (INHS) has had a strong focus on scientific collections. The INHS collections now total over 7.8 million specimens. Together with the almost 400,000 specimens from the University of Illinois collections that are managed by the Survey (see page 3), these holdings make up the second largest natural history collection in the state, and for most kinds of organisms are the most complete documentation of Illinois' flora and fauna available anywhere. This tremendous resource serves as the foundation for much of the Survey's research and educational programs. In this issue of *INHS Reports*, we provide an overview of the Survey's collections and their uses.

Photo from INHS image archives

INHS researchers on collecting expedition in 1894.

The INHS collections consist of specimens collected from throughout the world but with a strong emphasis on Illinois. They constitute a huge repository of biological information because a specimen consists not only of the preserved plant or animal itself, but also associated data. At a minimum, each specimen has with it information about where, when, and by whom it was collected; thus, the collections document the distribution of plants and animals through space and time. Additional data may also be recorded with the specimens or may be extracted if needed. For example, the size, age, and sex of the individual, its reproductive status, and what it had been feeding on may all be found for many animal specimens. Analyses can be run to determine levels of chemicals in plant or animal tissues, and DNA may be analyzed to determine relationships. This wealth of information makes collections invaluable for many scientific fields.

Traditionally, collections have been used primarily by systematists, scientists who study the diversity of life, particularly the evolutionary relationships among organisms, and determine appropriate names to be applied to populations. Using both morphology and molecular data, especially DNA, systematists determine the limits of species and develop classification schemes that reflect their relationships. Our knowledge about which species occur in Illinois depends on this use of collections.

Even in a state as well explored as Illinois, new species continue to be found. In some cases they are species that have invaded from elsewhere, but in other cases they are native species that have been overlooked by previous researchers. Without extensive collections, systematists would be unable to determine if unfamiliar species are newly discovered or are well-known species from other regions. This difference can have profound importance. A newly discovered species may need protection as a threatened or endangered species. An invader, by contrast, may require drastic control measures. The Asian longhorned beetle, which recently devastated hardwood trees in Chicago-area neighborhoods,

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Collections

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is a good example. Information on this and other invasive species can be found in the November/December 1998 issue of *INHS Reports*.

Increasingly, scientists are using collections in ways other than to identify and classify organisms. Because the origin of each specimen can be fixed in space and time, changes in plant and animal distribution can be uncovered using collection data. Computerization of specimen data, coupled with the use of Geographic Information Systems (GIS), make changing patterns easier to determine. Repeated surveys, especially using established sampling techniques, allow even more detailed documentation of species distributions and community composition. Surveys of fishes in Illinois, which now span 100 years, are good examples. The results of the third statewide survey, soon to be published, show that our fish fauna has changed dramatically, with nonnative species increasing and native species declining and even disappearing. The long-term monitoring efforts now under way through the Critical Trends Assessment Project will allow similar studies of other groups of organisms.

Photo from INHS image archives

INHS aquatic biologist Robert E. Richardson (left) and colleague collect fish in the Illinois River in 1910.

Nonscientists often ask why we maintain collections from earlier surveys. After all, once the name, date, and locality are recorded, why keep the specimen? The problem is that workers in different eras base their studies on different species concepts. For example, in his *Fishes of Illinois*, published in 1909, Stephen A. Forbes, a prominent scientist and first Chief of the Illinois Natural History Survey, assumed that many Illinois populations of small minnows with a prominent black stripe down their sides belonged to a species known as *Notropis heterodon*. Today, with improved information on Illinois populations, we know that what Forbes considered to be one species actually is three species. If we had only the published records, we would not know which localities were inhabited by which of the three species. Fortunately, by referring to the specimens that Forbes deposited in collections, we can determine the turn-of-the-century range in Illinois for each of the three species.

Not only can changes in species distributions be documented through collections, but so can changes in community composition. The red shiner is a small minnow that is common in the Great Plains and highly tolerant of warm turbid water. As riparian vegetation has been removed to create cropland, Illinois streams have become warmer and more turbid, and the red shiner has been able to move eastward across Illinois. Collection data from the late 1800s through 1998 show that as the red shiner has expanded its range, the related but less silt-tolerant spotfin, steelcolor, and blacktail shiners have become less common and less widely distributed in Illinois. Similar changes can be shown in crayfish communities, where the rusty crayfish, an invasive species introduced to Illinois about 1970, is spreading and rapidly increasing in numbers, whereas the clearwater and virile crayfishes, which occupy similar habitats, are showing declines, presumably because they are unable to compete with the larger and more aggressive rusty crayfish.

Targeting conservation efforts can be more effective with information from collections. Specimen data show that a few areas in Illinois support many more native species, often including rare species, than do other areas. These biologically outstanding areas therefore offer the best opportunities for protecting large numbers of native species. Gap analysis integrates information on these areas with GIS data on land ownership to identify "gaps" in protection. Because of its extensive collections and strength in GIS, INHS is the Illinois coordinator for the national gap analysis effort.

In a state like Illinois, which has so little high-quality natural habitat remaining, habitat restoration and even reconstruction are becoming increasingly important. Data on original species distributions and biological community compositions provide the benchmarks for projects designed to restore natural communities. Samples taken from project areas over time and preserved in the collections will allow us to measure their progress.

Continued on next page

Collections

continued from previous page

Changes in habitat quality can be demonstrated through collections in other ways. Often certain groups of species are particularly sensitive to environmental conditions, and are therefore good indicators of ecosystem health. Insects in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), collectively referred to as EPT, are outstanding indicators of stream quality. Historical EPT collections, made prior to extensive degradation of Illinois' streams, are being compared with modern collections to document remaining high-quality streams and quantify the changes in others. In the future, collections made today will be used to show how changes in land management locally and statewide have affected stream quality.

Sometimes collections can be used to document other forms of environmental change, notably the presence of chemical pollutants. Tissues extracted from specimens can be chemically analyzed, often with little damage to the specimens themselves. A classic example is the demonstration of increased DDT buildup in eggshells of several declining bird species, which is associated with thinning of the eggshells. This collection-based study contributed to the widespread ban of the use of this pesticide and the subsequent recovery of the bird populations. More recent studies have shown increases in other pesticides and heavy metals in fish and waterfowl. Without historical collections, made before the introduction of these pollutants, it would be impossible to demonstrate the changes they have caused.

The INHS collections are used not only by Survey staff but by scientists from around the country and the world. Much like books in a library, specimens in a collection can be studied either at the Survey or they can be borrowed for study at researchers' home institutions. In fiscal year 1997-1998, over 500 individuals visited the collections, and Survey staff sent out 172 loans totalling about 22,600 specimens. Researchers also get information via the collection Web sites and by requesting information directly from the curatorial staff; over 150 data requests were answered last year. In addition, the collections are widely cited in scientific publications. This intense use testifies to the importance of the INHS collections.

With continued modification of natural habitats and new ways to extract and utilize specimen data, the value of collections to society will increase. For many areas, the only records of a species' presence will be the specimens in institutional collections. Fortunately, INHS has collections that are among the largest and most valuable of any state-supported institution. The Survey is committed to building and preserving its collections, and making them and the associated data available to scientists, policymakers, and the other citizens of Illinois concerned with protecting the environment.

Geoffrey A. Levin and Lawrence M. Page, Center for Biodiversity

The University of Illinois Collections

Recently the University of Illinois and the INHS entered into a Memorandum of Understanding that calls for INHS to manage the university's zoological collections. Because of diminishing resources and changing priorities, the university is no longer able to provide the staff needed to oversee its collections. Rather than see the collections deteriorate or be dispersed, INHS has agreed to care for these collections. Many years ago the university's insect collection was transferred to INHS, and both institutions anticipate that the UI plant collections will be housed and managed by INHS when the new Survey building is completed.

The UI plant, mollusk, amphibian and reptile, and mammal collections are all large and scientifically very important. The bird collection, though relatively small, is historically important. Managing the INHS and UI collections together is more efficient and allows the vital data they contain to be integrated. Researchers and other users benefit by having the collections accessible and similarly managed. It should also be easier to attract funding from foundations for the larger combined collections. INHS is proud to be able to serve the scientific community and the people of Illinois as we continue our 140-year history of building and maintaining scientific collections.

Geoffrey A. Levin, Center for Biodiversity

Combined Collections: Illinois Natural History Survey and University of Illinois

Collection	No. Specimens (INHS Specimens)	Rank	Notes
Insects	6,250,000 (6,250,000)	9th largest in North America	Many types[1]; largest collection of Illinois material
Plants	830,000 (250,000)	16th largest in North America	Many types; largest collection of Illinois material
Fishes	765,000 (765,000)	15th largest in North America	Many types; largest collection of Illinois material
Mollusks	340,000 (99,000)	15th largest in North America	Many types; largest collection of Illinois material; 6th largest freshwater collection
Annelids	295,000 (295,000)		Only large collection of Illinois material
Crustaceans	165,000 (165,000)	15th largest in North America	Largest collection of Illinois material
Amphibians and Reptiles	111,000 (15,000)	9th largest in North America	Many types; largest collection of Illinois material
Mammals	62,000 (1,000)	15th largest in North America	Many types; largest collection of Illinois material
Birds	9,000 (3,500)		Includes extinct species
Microsporidia	1,000 (1,000)		Largest microsporidia collection in the world

[1] A type is a specimen designated to serve as a permanent physical representation of a species' scientific name when that species is first named.

How Scientific Specimens are Preserved

Several different methods are used to preserve specimens, depending on the type of organism and how the specimen will be used.

Drying. Used with mammal and bird skins, bones, mollusk shells, insects, and plants. Shells require little preparation. Skins are often stuffed after the flesh is removed. Bones must be thoroughly cleaned, a process that is often facilitated by putting the carcass in a colony of flesh-eating beetles. Insects are usually pinned or mounted on tiny paper "points." Plants are usually pressed flat, dried, and then glued on special highly durable paper.

Pickling. Used with amphibians and reptiles, fish, crustaceans, soft-bodied parts of mollusks, delicate insects, and other invertebrates. Grain alcohol (ethanol) is the standard preservative. The specimens are stored in appropriate-sized containers, including small vials, bottles, and even large steel tanks.

Slide mounting. Small insects and other invertebrates are often mounted directly on microscope slides, which allows them to be examined microscopically without handling. The genitalia of many larger insects are essential for identification and may also be mounted on a slide accompanying the insect. Slide mounting is also frequently used for fungi.

Freezing. Microsporidia, microscopic organisms that often infect insects, are best preserved by freezing at very low temperatures (-321°F) in liquid nitrogen, where they live in a state of "suspended animation" (see the article in this issue on the microsporidia collection). Many seeds can be stored, alive, the same way. Freezing can also be used to preserve both animal and plant tissue collections for DNA and other chemical analyses.

Living cultures. Collections of bacteria and many fungi are best maintained as living cultures. Obviously this requires intense labor, and few institutions are able to make the long-term commitment to maintaining living collections.

Geoffrey A. Levin, Center for Biodiversity

INHS Collections Databases

Imagine trying to keep track of the data associated with almost 8 million specimens! In the past the task would have been inconceivable, but with the widespread availability of computers, many institutions have begun entering their collection data into computerized databases. The INHS has been one of the leaders in computerization of natural history collections. The INHS Mammal, Amphibian and Reptile, Fish, Crustacean, Mollusk, and Plant collections all have complete and up-to-date electronic databases, and computerization of the INHS Insect and Annelid collections is currently under way. All told, data for nearly 1.5 million specimens have been entered. The databases are run in Claris Filemaker Pro primarily on Macintosh computers, but are also compatible with Windows.

Data from the collections have been used by scientists to develop lists of both state and federal threatened and endangered species and of introduced or harmful species. They have also been used to recognize outstanding natural areas and to formulate management plans for species. Information is supplied on request to other scientific research institutions, governmental agencies, universities, museums, and the general public on a routine basis for a variety of uses.

Several of the collections databases are searchable on the World Wide Web. Anyone with access to the Web can query the mammal, amphibian and reptile, fish, crustacean, and mollusk collections databases at http://ellipse.inhs.uiuc.edu/INHSCollections/. We offer a limited amount of information about each specimen on our Web site, but individuals are welcome to e-mail the appropriate curator and request further details. Programs used for Web access of the databases include WebSTAR, Lasso, and Filemaker Pro.

The INHS Geographic Information System (GIS) is being incorporated for use with our collections databases. The collections locations are plotted in the GIS and then the locality information in the Filemaker Pro file is linked to the GIS point. The location of each specimen can then be drawn on a computer-generated map. Distributions of individual species or groups of species can be plotted on paper, on the computer screen, and on the Web (see "Illinois Amphibian and Reptile Distributions" at http://www.inhs.uiuc.edu/cbd/herpdist/herp.html). By using our collections databases in conjunction with GIS, researchers are able to see changes in distributions of populations both in time and space. Gaps in species conservation can be assessed by combining collection data with GIS data on land ownership.

The Survey's biological collections are an important part of our knowledge of the biodiversity of Illinois. By entering the information into electronic databases, we are able to easily retrieve information and use it in different ways. We can also combine the collections data with other types of data already available in the GIS to help give us a better understanding of the plants and animals of Illinois.

Christine Mayer, Center for Biodiversity

Plant Collection

The Illinois Natural History Survey Plant Collection contains more than 250,000 specimens from four distinct groups of organisms: fungi, algae, bryophytes, and vascular plants. The primary emphasis is on the plants of Illinois; for example, 90% of of the vascular plants are from the state. Also included are specimens from all 50 U.S. states and 34 foreign countries. The vascular plants are the largest segment of the collection with more than 194,000 dried, labeled, and mounted plants. The fungus collection is the second largest segment with more than 54,000 dried, labeled fungi in packets. About 3,500 specimens are added annually to the plant collection, which is fully computerized to allow rapid information retrieval.

While the earliest Illinois collection at the Survey herbarium is a collection of *Galium aparine* (bedstraw) made by Foster Waltz from Macon County in 1873, the collection has had two major periods of development. During the 1940s–1960s the initially small collection was greatly expanded through the efforts of staff botanist R.A. Evers, who systematically sampled the flora throughout Illinois, adding about 100,000 specimens to the collection. The second major period of development began about a decade ago and continues today with the renovation of the facilities and expansion of staff who pursue botanical surveys both inside and outside of Illinois. Staff are focusing increasingly on the inventory and evaluation of state and private nature preserves and other high-quality natural areas and plant communities, including Site M, Savanna Army Depot, Chauncey Marsh, Momence Wetlands, Long Branch Sand Prairie, Vermilion River Observatory, and Stephen A. Forbes State Park, as well as numerous projects throughout the state associated with road projects by the Illinois Department of Transportation. Also of particular interest are the discovery and monitoring of federal and state threatened and endangered plant species, and recording and monitoring of the spread of exotic and weedy species.

Photo by Ken Robertson, INHS Center for Biodiversity

Botanist Rick Phillippe in the INHS Herbarium.

Loy R. Phillippe, Kenneth R. Robertson, and Steven R. Hill, Center for Biodiversity

Collections and Outreach

The extensive collections of the Survey provide a great resource for a variety of in-house and out-of-house outreach activities. Although the Survey is not set up for public viewing of its collections, the collections are often the focal point for Survey visitors, from kindergartners to legislators. Because of the complexity and diversity of the Survey, these impressive groupings of organisms provide an understandable entry into the work of the Survey. For many visitors, the collections are portrayed as, and indeed are, a great library of irreplaceable information—the biological memory of Illinois.

The collections serve other outreach functions, such as providing the "punch" for a traveling exhibit on biodiversity, serving as a resource for creating educational materials, or being included as objet d'art in a natural history photographic exhibit about Illinois. For the last six years, the Survey (in conjunction with the Geological and Water surveys) has had an exhibit entitled "Biodiversity in Illinois" that has visited nearly 60 sites around the state. Billed as "the exhibit that goes where no exhibit has gone before," the 1,000-square-foot exhibit has been in such diverse locations as a refurbished barn at a northern Illinois natural area, numerous middle and high school cafeterias, and visitor centers of national organizations, such as the U.S. Army Corps of Engineers. The heart of the exhibit is a selection of organisms from the Survey collections: mussels, mammals, fishes, birds, amphibians and reptiles (including all four Illinois poisonous snakes), and insects and other invertebrates. The exhibit has put thousands of people in touch with the Survey and the importance of its collections.

In conjunction with the Illinois EcoWatch program, the collections have served as invaluable resources for the production of training materials for volunteer "citizen scientists." EcoWatch is a program whereby citizens are trained in volunteer monitoring projects and collect ecological data from various Illinois habitats. Part of their training is in the identification of specific groups of organisms, for example, macroinvertebrates for RiverWatch and butterflies for PrairieWatch. The collections have provided the source materials for full-color field guides and cards that enable volunteers to correctly identify the target organisms.

Several of the research collections have smaller traveling or loaner collections that

Photo by Susan Post, INHS Center for Economic Entomology

INHS education/outreach coordinator Michael Jeffords helps kids plant a prairie in Chicago.

can be used by Survey personnel when they present programs away from the Survey for a variety of audiences. These collections include several displays of insects, a case of all the bat species found in Illinois, and displays on mussels and the mussel industry.

Just as the collections provide a valuable research resource for the state, they also provide the needed materials for education outreach to introduce this and coming generations to the life forms found in Illinois.

Michael R. Jeffords, Office of the Chief

Crustacean Collection

The INHS Crustacean Collection is the third largest collection of preserved freshwater crustaceans in North America, containing approximately 165,000 specimens representing 240 species. The geographic scope of the collection is about 64% from Illinois, 35% from elsewhere in North America, including 38 states and several Canadian provinces, and 1% from four countries outside North America. The majority of specimens housed in the crustacean collection are freshwater crayfishes in the Order Decapoda; freshwater shrimps (Decapoda), isopods (Isopoda), and amphipods (Amphipoda) make up the remainder of the collection.

A unique aspect of the crustacean collection is that it is completely computerized and on-line. No other major collection of freshwater crustaceans in the United States offers Internet browsers the opportunity to search and download records from a complete collections database. In the computer database, a unique catalog number is assigned to each lot (all specimens of one species collected on the same day at the same site) and information entered for each lot includes species name, the collection location, date of collection, and names of collectors. Each lot is annotated with a stream-drainage code that numbers Illinois' waterways in a hierarchical fashion and enables us to group collections according to a specific stream or drainage basin. A typical request for information asks which species occur in a particular stream, or which localities in a given area contain a particular species.

As with the fish collection, the crustacean collection was established in the late 1800s to provide documentation of the state's fauna. In 1876 the first Chief of the Illinois Natural History Survey, Stephen A. Forbes, published a *List of Illinois Crustacea, With Descriptions of New Species*. This publication was one of the first state faunal lists of crustaceans in the United States and provides baseline data on the distribution and habitat of numerous Illinois crustaceans. This information will prove useful in the future as we begin to document the effects of human activity on crustaceans. Given its large holdings of crayfishes, the crustacean collection is also used by crayfish taxonomists working on the descriptions of new species and the plotting of species distributions.

Christopher A. Taylor, Center for Biodiversity

Microsporidia Collection: An Unusual (and Living) Resource

A mention of the INHS collections elicits visions of glass-topped Cornell cases stacked 10 feet high, holding rows of pinned and carefully labeled butterflies, beetles, and other insects. Perhaps a visitor will see drawers of carefully stored birds and small mammal skins, each stuffed with cotton and awaiting study. Shelves of glass jars and vials hold small invertebrate animals and primitive plants in preservative fluids, as well as pressed and dried herbaceous plants in a neatly organized herbarium. In addition to these dead and preserved biological wonders, INHS houses other kinds of collections, some of which may be a surprise to visitors. One such collection is probably the world's largest and most diverse accretion of living entomopathogenic microsporidia, protozoa-like organisms that cause chronic or acute disease in insects.

Microsporidia are single-celled organisms with one or two nuclei and are always parasitic. They are sufficiently unique to be assigned to their own phylum, Microsporidia (formerly Microspora). Approximately 1,000 species have been described, most from insects and other invertebrates, but species have also been found infecting most other animal groups, including man.

Microsporidia are typically host-specific and those species collected from insects cannot survive the warm body temperatures of mammals and birds. The "mature" forms of microsporidia are environmentally resistant spores or "environmental spores." Millions of these spores are produced per individual host late in the infection process and enter the environment via feces, silk trails, or decomposed tissues of dead hosts. Other individuals of the same host species become infected when they ingest these spores. Many microsporidian species are also transmitted from infected females to their offspring inside or on the surface of the eggs.

Unlike preserved collections, the different species of microsporidia in the INHS collection are kept in a living state, cryofrozen at -321°F in liquid nitrogen. Approximately 1,000 samples, representing more than 100 species of microsporidia, have been collected over the past 30 years. Environmental spores are suspended in purified water and placed into small polypropylene cryovials. The vials are snapped onto a stainless steel "cane" and suspended in liquid nitrogen tanks. Our studies have shown that by adding 50% glycerin by volume and a small amount of antibiotic and fungicide to each cryovial to retard bacterial and fungal growth, the spores will live almost indefinitely in a state of suspended metabolism. Spores we tested after 25 years of storage were still viable and infected their hosts when ingested.

Specimens from the collection at INHS are used by insect pathologists all over the world. We provide spores to our research cooperators for studies in systematics and evaluation as possible biological control agents for insect pests. We investigate the infective processes of microsporidia to determine the effectiveness of these diseases in reducing insect populations. In addition, we can make comparisons between species of microsporidia using techniques that were not available when the microsporidia were first collected. Another function of the insect pathology laboratory staff is to assist persons rearing insects for scientific or commercial endeavors who discover unwanted diseases in laboratory colonies or beneficial insects. The collection is a valuable resource for insect pathologists and for studies of these fascinating organisms.

Leellen F. Solter and Joseph V. Maddox, Center for Economic Entomology

Photo by Lee Solter, INHS Center for Economic Entomology

Stephen Lavallee (left) and Diego Roman of INHS store insect pathogens in a liquid nitrogen tank.

Mollusk Collection

The INHS Mollusk Collection is one of the oldest in North America with specimens dating back to 1861. It was inactive for over 35 years but was "resurrected" about 1985. In March 1998, curation of the mollusk collection of the University of Illinois Museum of Natural History (UIMNH) was transferred to the Illinois Natural History Survey. One of the 15 largest mollusk collections in North America, the combined INHS–UIMNH Mollusk Collection contains over 300,000 cataloged specimens in approximately 65,000 lots. Approximately 300 lots contain type specimens, which are primarily terrestrial and freshwater midwestern gastropods.

The collection is strong in midwestern freshwater bivalves (especially mussels or unionids) and freshwater and terrestrial gastropods, with a secondary emphasis on the bivalves and freshwater gastropods from the southeastern U.S. and Venezuela. The freshwater bivalves number over 80,000 cataloged (>22,000 lots) and approximately 18,000 uncataloged specimens. More than 21,000 soft parts of more than 150 species have been preserved and are available for study. In addition, many marine and non-North American terrestrial and freshwater species are represented but they still need to be inventoried.

Most of the specimens were collected as a result of faunal surveys conducted by zoologists during the late 1800s until the present. The UIMNH collection was largely assembled by Frank Collins Baker and Anson A. Hinkley. Baker was considered by many to be one of the "deans" of malacology (the study of mollusks), and he published over 250 papers based largely on specimens in the collection, including large monographs on the Mollusca of the Chicago area (two volumes 1898, 1902), the Lymnaeidae of North and Middle America (1911), the Mollusca of Wisconsin (two volumes, 1928), a fieldbook of Illinois land snails (1939), and the molluscan family Planorbidae (1945).

Born in Indiana, Anson A. Hinkley lived most of his life in Rockford and DuBois, Illinois, where he died in 1920. Hinkley was a tireless collector and, although he published little, the results of his collecting endeavors can be found in museums throughout the United States. Of particular importance are his turn-of-the-century collections from the southeastern U.S., which helped to document the diverse molluscan fauna of that region. Hinkley is credited with discovering approximately 115 new species (15 of which were named after him), a record of accomplishment that secures his place in the study of North American mollusks.

The collection also contans specimens collected by other early naturalists, including Richard Ellsworth Call and Lorenzo E. Daniels, both of whom worked extensively in Illinois, Iowa, and Indiana; John Wesley Powell, pioneer explorer of the Grand Canyon and first curator of zoology of the Illinois Natural History Society; Robert Kennicott, one of Illinois' first naturalists; and Max R. Matteson of the University of Illinois, who conducted a statewide survey of mussels in the 1950s.

The INHS-UIMNH mollusk collection is of great value to the state of Illinois, and one of its most important aspects is its age. Many of the specimens were collected around the turn of the century and represent a "snapshot in time" of the species and conditions that occurred in Illinois and other parts of the country. The collection was instrumental in forming the current list of Illinois threatened or endangered mollusk species. Without the historical perspective the collection provides, it would be difficult to assess the current status of many mollusk species. The geographic scope of the collection will help in providing data for a new North American mussel atlas project aimed at conserving mussels in Illinois and across North America. Many of the species found in the collection are extinct and their shells are all we have to document their former occurrence. For example, the collection contains numerous freshwater snail species now extinct due to changes in the hydrology of the Alabama River system. Much information remains to be "unlocked." By computerizing the data scientists can begin to look at other groups (i.e., land and freshwater snails) to determine the status of those species and protect the biodiversity of Illinois and the U.S. for future generations. All of the INHS cataloged specimens have been computerized and significant progress has been made in computerizing the UIMNH holdings.

Photo courtesy of Kevin Cummings, INHS Center for Biodiversity

Anson A. Hinkley (1857-1920)

Photo courtesy of Kevin Cummings, INHS Center for Biodiversity

Frank Collins Baker (1867-1942) with the UIMNH Mollusk Collection, circa 1935.

Kevin S. Cummings and Christine A. Mayer, Center for Biodiversity

Annelida Collection

The Phylum Annelida consists of the segmented worms, including earthworms and their relatives the aquatic oligochaetes, leeches, crayfish worms, suction-feeding worms, and a large number of mostly marine worms known as polychaetes. The INHS Annelida Collection [http://www.inhs.uiuc.edu:80/~mjwetzel/INHS.annelcoll.html] is perhaps the largest state collection of freshwater oligochaetes in the country, holding almost 300,000 specimens (over 6,200 lots, or collections). Approximately 206,000 specimens are permanently mounted on microscope slides; the remaining specimens are stored in alcohol in vials and jars. The collection includes representatives of five of the six classes in the Annelida, the exception being the Acanthobdellae, or bristle worms, which includes only a single boreal species. Many worm species that have limited known distributions in North America are included in the collection. Several aquatic annelid species occurring in Illinois are of particular interest in that they are restricted to specific habitats in the state and to a limited number of sites elsewhere in North America.

The geographic scope of the INHS Annelida Collection is about 74% from Illinois; 25% from elsewhere in North America, including collections from 47 states, 5 Canadian provinces, and a few localities in Mexico; and 1% from about a dozen countries outside of North America, including the Caribbean Islands, India, South America, and Sweden. Specific surveys for aquatic annelids as well as general surveys for all aquatic macroinvertebrates conducted by INHS biologists since 1973 have contributed the vast majority of the specimens to the INHS Annelida Collection.

Stephen A. Forbes, the first Chief of the Illinois Natural History Survey, was the first scientist to describe an annelid species from Illinois—and a unique one at that! *Haemopis eonops*, the American terrestrial leech, was described (as *H. terrestris*) by Forbes in 1890 from a garden at Normal in McLean County. This species is the only terrestrial leech in North America. This species is our second largest, often reaching a length of over 28 centimeters (11 inches)! Rarely collected from flowing or standing water, *H. eonops* prefers muddy, bottomland habitats near streams; it feeds primarily on earthworms and other invertebrates, but never on the blood of animals.

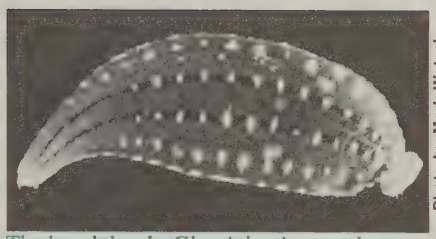


Photo by Mark Wetzel, INHS Center for Biodiversity

The brook leech, *Glossiphonia complanata*.

Additional information focusing on annelid research in Illinois and around the world is available from the World Wide Web site, The INHS Center for Annelida Resources: http://www.inhs.uiuc.edu:80/~mjwetzel/mjw.inhsCAR.html.

Mark J. Wetzel, Center for Biodiversity

Mammal Collection

The INHS Mammal Collection contains approximately 1,000 specimens, most of which are from Illinois. Many of the specimens were collected by Dr. Philip W. Smith between 1930 and 1950, but the oldest specimens date back to the early 1900s. The collection provides nearly complete taxonomic coverage of the mammal species that occur in Illinois. The collection also has proven very useful for educational outreach. For example, a display case containing specimens of the 12 bat species found in the state has traveled (accompanied by curator Joyce Hofmann) to nearly two dozen schools in central and northern Illinois as well as several nature centers, museums, and special events.

INHS also has assumed curatorial responsibility for the University of Illinois Museum of Natural History (UIMNH) Mammal Collection, which contains more than 61,000 cataloged specimens, including 20 type specimens. In 1987 the UIMNH was ranked as the 11th largest mammal collection in North America. Although the collection has not been active in recent years, it probably remains among the continent's top 15 collections. Former curator Dr. Donald F. Hoffmeister has been a major figure in the field of mammalogy and trained many of the professional mammalogists now active around the country. Dr. Hoffmeister is the author of *Mammals of Arizona* (1986) and *Mammals of Illinois* (1989), and the UIMNH houses large collections of specimens from these states. The collections of mammals from the midwestern and southwestern U.S. are of major importance because they include documentation of the historical distributions of species in these regions as well as important taxonomic specimens. The combined mammal collections—almost every mammalian family is represented—contain specimens from every state except Hawaii and more than 30 foreign countries.

The INHS and UIMNH Mammal Collections are an important resource for biologists working in Illinois. They document the past distribution of mammals in the state and provide a benchmark against which to compare current distributions and changes induced by modern land use. They also include valuable data on the taxonomy and genetic diversity of Illinois' recent mammalian fauna that could become useful for studies of conservation genetics as new techniques to extract information from the DNA in museum specimens are developed.

Edward J. Heske, Center for Wildlife Ecology, and Joyce E. Hofmann, Center for Biodiversity

Insect Collection

The INHS Insect Collection is a state and national resource. During the past 140 years the collection has grown exponentially to over 6,250,000 specimens and is now the ninth largest insect collection in the United States. It occupies over 8,000 drawers, 28,000 vial racks, and 180,000 slides. The collection is worldwide in scope, and has formed the basis for numerous widely cited revisions, evolutionary studies, and identification guides.

The oldest specimen in the collection dates back to 1860 and was collected by B.D. Walsh, Illinois's first State Entomologist. An avid collector, Walsh knew the importance of an insect collection for entomological studies. The eccentric and gifted Walsh was known to wear a cork-lined hat to which he would pin insects collected on his walks. Even when Walsh had his left foot amputated after a railway accident, he was heartened by the fact that he could use his cork prosthesis to collect more insects. Only a few of Walsh's original 10,000 specimens still exist. Most of his collection was sent from Springfield to Chicago in 1871 for safe-keeping, but ironically all but the synoptic collection left in Springfield was destroyed later that year in the infamous Chicago Fire.

The need for a reference insect collection for entomological research in the state was recognized during the 1850s at a time when the residents of Illinois were becoming increasingly aware of the destruction and devastation caused by native insects to their cultivated crops. Insects were studied and collected to help understand how to eradicate or limit their populations. The collection is still used for the identification of pest species. This past year Illinois has seen its share of exotic "invaders." One was the pesky but harmless lady-bird beetle, *Harmonia axyridis*, which swarms in large numbers in autumn, entering homes through cracks and crevices. This insect was imported from eastern Asia and first appeared in large numbers only a few years ago. Its arrival and distribution in the United States can be tracked by referring to the specimens in the INHS Insect Collection as well as in other collections throughout the nation.

Another introduced species that appeared this past year in Illinois is an extremely serious pest, the Asian longhorned beetle (*Anoplophora glabripennis*). This beetle is capable of destroying mature trees and currently the only way to stop its spread is to destroy the invaded trees. Its identity was confirmed by comparing specimens to those from an insect collection.

Our collection documents not only insect presence and distribution, but the numbers of specimens in the collection provides an indication of their abundance. Present studies in our native remnant prairies suggest that not only are some of our native insects no longer found in the same locations, but when found are often in only a fraction of the numbers known in the late 1800s or early 1900s.

Not only is the collection used for research and identifications, it also is recognized for its inherent beauty. The insects in the collection have been viewed by artists, photographers, film crews, even software designers, for use in their work. Many of the specimens are jewel-like, have unique and bold color combinations, and are of such unusual shape and design as to capture our imaginations. The INHS Insect Collection has been an invaluable tool for the study of entomology in the state and world and will continue to be a priceless storehouse of information for future scientists and the public.

Kathy R. Zeiders, R. Edward DeWalt, David J. Voegtlin, Christopher H. Dietrich, and Donald W. Webb, Center for Biodiversity

Photo by Kathleen Zeiders, INHS Center for Economic Entomology

Some of the butterfly specimens in the INHS Insect Collection.

International Soybean Arthropod Collection

The International Soybean Arthropod Collection (ISAC) is a large, commodity-oriented assemblage of insects and other arthropods that is supported by an electronically maintained database containing taxonomic and ecological information. ISAC was begun in 1970 to survey arthropods of soybeans and document their ecological associations from soybean-producing areas of the United States and the world, monitor the major pest species and their natural enemies for possible changes in geographic distribution through time, and provide arthropod identification services for soybean researchers, extension specialists, and producers around the world.

The extensive assemblage of arthropods associated with soybeans is unique. ISAC currently comprises nearly 300,000 arthropod specimens. Extensive as well as intensive arthropod surveys of all the major soybean growing regions of the United States were undertaken in the early to mid-1970s. That material serves as the backbone of the collection. In addition, the collection contains arthropods from over 40 other countries. The only other collection that comes close in coverage of commodity-associated arthropods is the rice arthropod collection maintained at the International Rice Research Institute in the Philippines.

Quantitative as well as qualitative data are associated with most of the specimens because these specimens were sampled in a quantitative manner. Thus, population density information is associated with most of the samples, something that can be used to compare densities among sampled sites. Beyond this, meaningful data about soybean cultivar, planting practices, prior pesticide use, neighboring crops, weediness of field, and other ecological factors are tied to each specimen through a set of detailed, site-specific data sheets.

Such a collection could yield tremendously important information about arthropod communities associated with soybeans in differing environmental zones and under differing cultural practices. The collection includes both phytophagous arthropods and their natural enemies; thus, critical information about the effect of pesticide use on predators and parasitoids could be teased from the data. Valuable insights into the trophic complexities of arthropods in soybean fields in different parts of the world can be gleaned from the collection. There can be no doubt that this is a unique and priceless database, one that contains information that can help interpret biological and ecological relationships from the very practical to the very basic. Unfortunately, this unique and valuable collection was mothballed more than 10 years ago when, for lack of funds, the International Soybean Program's commitment to the collection waned. During the collection's heyday, hundreds of thousands of dollars were expended on expeditions, curation, and storage. The collection is housed with the INHS Insect Collection, but it remains to be seen if a funding source can be found to revitalize the collection.

Michael E. Irwin, Center for Economic Entomology

Bird Collection

The INHS Bird Collection consists of approximately 3,500 specimens of 157 species, of which approximately 1,600 are Canada Geese. The Canada Goose collection is the largest in the U.S., if not the world, and forms the basis for ground-breaking information on Canada Goose taxonomy, soon to be published. The rest of the collection dates from the 1950s through the 1970s and is almost exclusively from Illinois. Although relatively small, the collection includes such rare species as Sprague's Pipit (*Anthus spragueii*) and a very large sample (over 200 individuals) of the Gray-cheeked Thrush (*Catharus minimus*), a common migrant. Many of the specimens were dead when collected at the bases of television towers statewide, documenting comparative mortality of birds at these structures.

The collection also includes an impressive egg collection gathered between the late 1880s and early 1930s, donated to INHS by Arthur Blocher. This collection consists of hundreds of egg sets representing hundreds of species collected not only in Illinois but from throughout the United States as well, and includes many species not found in Illinois. There is a modest nest collection as well.

The University of Illinois collection, which INHS now manages, complements the INHS collection nicely. There are many excellent specimens of species collected outside this country, including representatives from such diverse groups as penguins (Spheniscidae), woodcreepers (Dendrocolaptidae), hoatzin (Opisthocomidae), and even kiwis (Apterygidae).

Two studies demonstrate the utility of the INHS bird collection. In a study conducted during 1971–72, Loggerhead Shrikes, a declining, state-threatened species, were collected in some numbers statewide. The resulting analysis determined that the birds were accumulating DDE, a metabolite of DDT, in their tissues and their eggshells, suggesting that DDE in the environment was contributing to the decline of Loggerhead Shrike populations in Illinois. More recently, INHS researchers extracted DNA from feather roots of INHS specimens of the state endangered Greater Prairie Chicken (*Tympanuchus cupido*) collected during the 1930s and 1960s. These samples demonstrated that these earlier populations contained high levels of genetic diversity that was subsequently lost as the Prairie Chicken populations declined. This was apparently the first study providing direct evidence of reduction of genetic variation in a wild population through a historical range contraction. The study thus emphasized the value of museum collections as sources of genetic information from past or extinct populations for addressing questions of ecological importance.

Steven Bailey, Office of the Chief

Fish Collection

The INHS Fish Collection is the 15th largest collection of preserved fishes in North America and contains approximately 765,000 specimens representing 2,000 species in 142 families. The geographic scope of the collection is about 50% from Illinois, 30% from elsewhere in North America, 18% from South America, and 2% from other parts of the world. Included are collections from 47 of the 50 states and 23 foreign countries.

Among the collection's most valuable holdings are its type specimens. When a species is described as new to science, the author designates type specimens to serve as permanent physical representations of the species' scientific name. The fish collection contains 70 primary type specimens representing 34 named species and 2 subspecies. Included are 10 species described from Illinois in the late 1800s by Stephen A. Forbes, the first Chief of the Survey.

The fish collection was established in the late 1800s to provide documentation for the original survey of the fishes of Illinois (published in 1909 by S.A. Forbes and R.E. Richardson). A second survey (*The Fishes of Illinois* published in 1979 by P. W. Smith), designed to examine changes in fish populations since the first survey, was conducted in the mid-1900s and added 286,000 specimens to the collection. Many specimens from the early surveys are from areas where the species no longer occur and, therefore, provide irreplaceable distributional and ecological information. A third survey to look at changes in the distributions and abundances of fishes in the past 100 years is under way and will rely heavily on information associated with collection-housed specimens from the earlier surveys.

Orange-spotted sunfish drawing from Forbes and Richardson's the *Fishes of Illinois* published in 1909.

The first survey documented the presence in Illinois of 187 native and one non-native species. From specimens collected during the second survey we know that by 1978 the number of native species of fishes reproducing in Illinois had dropped to 179 and the number of non-native species had risen to 6. Recent data suggest that only 176 of our native fishes remain, many surviving species are undergoing large changes in their distributions, and the number of non-native species reproducing in Illinois has increased to 12. Most of the changes are results of anthropogenic effects such as increased sedimentation, channelization, pollution (particularly from nonpoint sources such as agricultural fertilizers and pesticides), and introductions of non-native species.

Environmental impacts on Illinois species do not result only from activities occurring within the borders of the state. Specimens from other geographic areas not only help us understand changes taking place in Illinois, but increase the usefulness of the collection to ichthyologists throughout North America and abroad. Recent collections from South America in particular have increased the collection's loan activity over the past two years by 45% and established the Survey as the seventh largest collection of Neotropical fishes in North America. The Neotropical specimens also enhance the collection's attractiveness to visiting elementary school students hoping to see and touch a real, albeit dead, piranha or electric eel.

Lawrence M. Page and Mark H. Sabaj, Center for Biodiversity

Photo from INHS image archives

A small portion of the INHS Fish Collection preserved in ethanol.

Amphibian and Reptile Collection

The INHS Amphibian and Reptile Collection contains approximately 14,800 cataloged specimens representing 55 families and over 550 species (50% amphibians, 50% reptiles). Over 100 specimens were collected before 1900. The geographical emphasis is Illinois (66%), the result of the efforts of Philip W. Smith, who collected specimens from 1935 to 1949. In addition to the Illinois material, the INHS collection also houses specimens from 45 other U.S. states, Canada, the Caribbean, Mexico, South America, Asia, Africa, and Europe. Most notable among these are specimens collected by Philip W. Smith from California (1943-1952) and Mexico (1957-1965); specimens of Sherman A. Minton from Pakistan, Mexico, and Texas; and specimens from Thailand collected by R.W. Larimore (1963).

Philip W. Smith was the most influential curator of the INHS Amphibian and Reptile Collection. A native of Illinois, Smith was a renowned herpetologist and ichthyologist who published over 100 scientific papers on amphibians, reptiles, and fishes. He also authored two books, *Fishes of Illinois* and *Amphibians and Reptiles of Illinois*, both of which are still considered outstanding examples of regional natural history books. Phil Smith curated the INHS Amphibian and Reptile Collection from 1952 to 1978.

In March 1998 curation and management of the amphibian and reptile collection of the University of Illinois Museum of Natural History (UIMNH) was transferred to the Illinois Natural History Survey. With nearly 100,000 cataloged specimens, it is one of the largest amphibian and reptile collections in North America. The geographic emphasis is Mexico, but there are large holdings from the United States, Canada, Ecuador, Cuba, the Philippines, and Venezuela. There are approximately 2,000 type specimens, including over 120 primary types. With the exception of a few skeletons and dried skins, the vast majority of the specimens are preserved in ethanol.

The UIMNH collection was largely assembled by Hobart Smith, curator from 1947 to 1968. In addition to adding thousands of specimens from his and his students' research, Smith was instrumental in acquiring other collections, most notably those of Edward Taylor, Chapman Grant, and Frederick Shannon. The UIMNH collection also includes specimens collected by other famous herpetologists, most notably Hobart Smith's mentor, Edward Taylor, whose Mexican collection is the most extensive in the world. Other collectors include Robert Ridgeway, an ornithologist who collected in Richland County, Illinois, early in this century; Alvin Cahn, who collected throughout Illinois in the 1930s; and Chapman Grant, who collected in Cuba and Guatemala in the 1950s.

Photo by Michael Redmer, Forest Preserve District of DuPage County

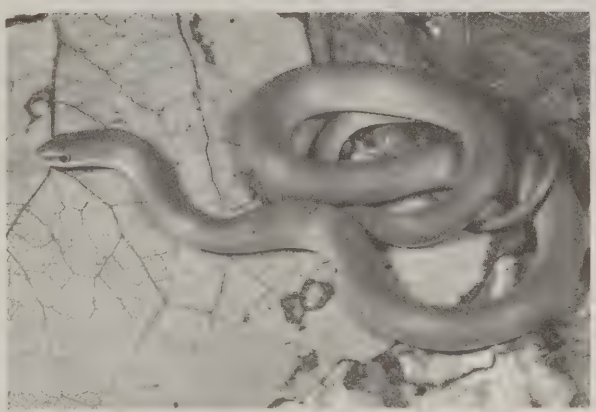


Photo by Michael Redmer, Forest Preserve District of DuPage County

Top: Ouachita map turtle, *Graptemys ouachitensis*.

Middle: Smooth green snake, *Opheodrys vernalis*.

Photo from INHS image archives

Left: Philip W. Smith, renowned INHS ichthyologist and herpetologist in the 1950s.

Photo by Michael Redmer, Forest Preserve District of DuPage County

The green tree frog, *Hyla cinerea*.

Christopher A. Phillips, Center for Biodiversity

Species Spotlight

Bloodroot

Susan Post

Bloodroot, *Sanguinaria canadensis*, a wild, white poppy of early spring, is a common perennial of rich, well-drained woods where it usually forms small colonies of plants. As one of the early wildflowers, it faces the hazards of a late frost that will cause its flower petals to fall off. Like other early spring wildflowers, it has white, bowl-shaped, sun-following flowers with reflective petals. The flowers stay warmer than the surrounding air as they reflect visible light onto the flowers' reproductive organs. These tiny solar ovens speed the development of pollen, seeds, and fruits, and aid in the survival of the visiting insects by providing them with a warm microenvironment.

Photo by Michael Jeffords, INHS Center for Economic Entomology

Bloodroot, *Sanguinaria canadensis*.

When the plant first emerges, the single silvery-green leaf is wrapped protectively around the flower stalk. As the plant develops, the flower stem raises the flowers above the level of the leaves. At this stage the solitary white flower, with 8 to 10 petals and a golden-orange center, is prominent. The flowers open wide when the sun strikes them and close when evening comes. These flower petals quickly disappear with the slightest breeze. The leaves stay curled around the base of the stem and unfurl to their full width only after the plant is pollinated. The heart-shaped leaves, with 5 to 7 lobes, will continue to grow around the petal-less stem, and by midsummer will be 3 to 4 inches across.

Once pollinated, the female part of the flower will develop into a slender seedpod called a capsule. Within the capsule are seeds that have a gelatinous crest. Ants are attracted to the gelatin and in collecting the gelatin disseminate the seeds.

The plant has several common names. Bloodroot comes from the orange-red juice in its roots and stem that was used in pioneer days to cure coughs, colds, and skin diseases. Early settlers would put a drop of sap on a lump of sugar for cough medicine, but it had to be taken sparingly, as the roots are slightly poisonous. Native Americans used the plant as a dye for baskets and clothing and for painting their faces and bodies. This gave rise to another common name—Indian paint. It was also known as red puccoon; puccoon came from the Native American word "pak," the term for any red-juiced plant used for staining and dyeing.

To see bloodroot, visit your favorite rich woods during March and April. Some good spots are Beall Woods, Fort Sheridan Nature Preserve, and Lake Argyle State Park.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

Purchase bleached or natural colored wool (wool felt is good if you can find it), silk, cotton, or linen fabric and cut into pieces for dyeing. If the fabric you choose has a tendency to fray, cut with pinking shears (1 1/2" by 6" is a good size for a bookmark). Prewash the fabric in mild, natural soap. This will remove any chemicals that have been added in the manufacturing process. Artificial fibers (polyester, nylon, etc.) will not take up natural dyes.

If you are using a fabric made of plant fibers (cellulose), pretreating will help it bond with the dye. Soak the cotton or linen for one hour in warm water with 1/4 teaspoon alum added for each pint of water added (alum is available in the spice section of the grocery store). Do not boil the fabric in the solution, and avoid stirring, because this causes fabric to shrink. Transfer fabric to a bath of warm water with 1/16 teaspoon of tannic acid powder per pint of water (available in drug stores) for one hour, then return it to the alum warm water bath for a final hour. Allow the water to cool to room temperature before removing the fabric, and then rinse it well with lukewarm water. This pretreatment is called mordanting, and it helps the fiber take up the dye by breaking chemical bonds on its surface. These bonds will reform with the dye. For animal fibers (protein), alum in the dye bath is adequate. While mordanting is not absolutely necessary for dyeing, it allows more dye to be picked up, so the colors will be more vivid.

Gather several glass pint jars with lids. You can use one for each student or one for each dye treatment. There are several different "treatments" that can be done to the dye to produce different results; you may want to experiment with several of them. Certain metals, such as iron or copper, can alter the color of the dye. Experiment with adding pennies (copper) or rusty nails (iron) to some of the jars. Try mixing more than one type of plant in one jar to get new colors. Results will also vary depending on pH and hardness of the water. Experiment by adding vinegar to make solutions more acidic or ammonia to make them more alkaline.

If you collect your own plant materials, be sure to have permission from the land owner, and do not collect threatened or endangered species. It is also recommended that you never remove more than 1/4 of a plant or group of plants; leave plenty behind to regenerate.

The Naturalist's Apprentice

Dyeing With Plants

Carolyn Nixon

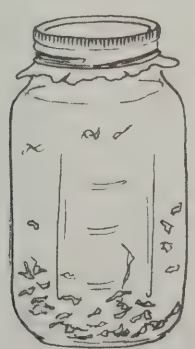
Using the Power of the Sun to Dye Cloth with Natural Plants

All plants contain pigments, often in large enough concentrations that they can be used to dye natural fibers such as wool or cotton. Many North American plants were used by Native Americans to produce a wide range of colors. The immigrants to North America also brought dye plants with them, some of which have escaped cultivation and are now naturalized across the landscape. Also, many plants commonly grown in the home garden can yield colorful pigments. While the process of extracting the pigment from the plant materials was usually done in a pot over a fire, Native Americans would often just chop up plants, put them in a container of water, add the yarn, and let it sit in the sun for a few days. Very good results are also possible by making "sun tea" from chopped or crushed plants.

Collect plant materials to extract the pigment. Check the table below for recommendations of plants that will give good results. Be sure to collect the correct part of the plant, as not all parts contain the same amount of pigment. Fill a clear glass jar (pint or larger) with the chopped leaves, stems, or roots, or with crushed berries, and then add water to within one inch of the top. Place the lid on the jar. If the lid is made of metal, be sure to line it first with plastic wrap or waxed paper because contact with the metal will affect the dye. Set the jar in a warm, sunny place to brew a tea from the chopped plants. After 2 to 4 days, strain out the plant material by pouring the liquid through a plastic strainer into a clean jar. Discard the plant material. Add 1/4 teaspoon of alum for each pint of liquid. Stir with a wood or plastic spoon until it dissolves. This will help the cloth to take up the dye. Now add pre-wetted strips of white cotton, linen, silk, or wool cloth to the liquid, pushing them into the jar and spreading them around evenly with the spoon. Do not stir, as this may cause the fabric to shrink. Also, do not pack them in tightly or the color will be uneven. Now, put the lid on the jar and set it back in the sun. Remove the cloth from the dye solution after 1 to 4 days.

Rinse the strips in clear water (do not scrub) and lay them on paper towels to dry.

Plant	Part of Plant	Color
Black Walnut (*Juglans*)	nut husks	gold or brown
Black-eyed Susan (*Rudbeckia*)	flowers	green
Cattail (*Typha*)	leaves	beige or green
Chicory (*Chicorium*)	stems, leaves, and blooms	yellow or green
Wild Cherries (*Prunus*)	leaves	gold, green, pink, or brown
Blackberries or Raspberries (*Rubus*)	fruit	pink, purple, gray
Cottonwood (*Populus*)	green leaves and twigs	yellow
Dandelion (*Taraxacum*)	whole plant including roots	beige or green
Goldenrod (*Solidago*)	leafy shoots or flowers	brown or yellow
Osage Orange (*Maclura*)	any part of plant	tan, khaki, or gold
Plantain (*Plantago*)	stem, leaves, and blossoms	green or gold
Ragweed (*Ambrosia*)	stems, leaves, or blooms	gold or green
Sedge (*Carex*)	blooming stems	tan, gold, or green
Rose (*Rosa*)	twigs, leaves, or rose hips	yellow or green
Willow (*Salix*)	leaves or twigs	yellow or green



ILLINOIS
NATURAL
HISTORY
SURVEY
607 East Peabody Drive,
Champaign, Illinois
61820 USA

Illinois Natural History Survey Reports is published bimonthly by the Illinois Natural History Survey, 607 East Peabody Drive, Champaign, IL 61820. Headquartered on the campus of the University of Illinois at Urbana-Champaign, the Survey is a division of the Illinois Department of Natural Resources

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INHS Collections on the World Wide Web

Widespread use of the Internet has tremendously increased access to collections, including those at INHS. Many of the collections databases can be searched via the World Wide Web. Staff are also working to link the INHS Geographic Information System to allow remote users to produce maps showing species distributions based on up-to-the-minute collection data. Although this capability is currently limited to the amphibian and reptile collection and a small part of the insect collection, mapable data sets are increasing rapidly. Check the INHS Web site at http://www.inhs.uiuc.edu/inhshome.html regularly for updates.

The following links currently provide access to INHS collections and related resources:

- Collection databases: http://ellipse.inhs.uiuc.edu/INHSCollections/

- Illinois Amphibian and Reptile Distributions: http://www.inhs.uiuc.edu/cbd/herpdist/herp.html

- Distribution maps for 29 stonefly species known from the Rock and Upper Mississippi rivers in Illinois: http://www.inhs.uiuc.edu/cbd/EPT/index.html

ILLINOIS NATURAL HISTORY SURVEY

Reports

ILLINOIS NATURAL RESOURCES

May/
June 1999
No. 357

INSIDE

Photo by Dwayne Etter, University of Illinois

Deer in the Suburbs of Chicago

The management of overabundant deer populations in suburban areas continues to be one of the most immediate and frustrating problems facing conservation and wildlife professionals nationwide. As rapid development encroaches on the remaining open landscapes surrounding most metropolitan areas, wildlife is forced into ever-shrinking islands in a sea of development. This concentration of wildlife into smaller and smaller areas causes intraspecific competition for the remaining available resources. In particular, overabundant white-tailed deer can cause severe impacts to ecosystems through excessive browsing, and they also pose threats to public safety through deer-vehicle collisions and the potential spread of wildlife-borne diseases.

The solutions to managing overabundant deer in suburban settings are often controversial, posing new challenges to managers. The traditional method of population control, recreational hunting, is unacceptable to urbanites. Additionally, despite the proliferation of literature published about deer, little research has focused on the biology of this species in its newly exploited suburban environment. Basic life history information is crucial to managers attempting to reduce and then maintain ecologically responsible suburban deer populations using alternative management techniques.

Photo by Dwayne Etter, University of Illinois

Fawn in suburban Chicago.

With funding from the Forest Preserve Districts of Cook and DuPage counties, Cook County Animal Control, and Chicago Wilderness, we are developing a model to predict population trends in suburban deer and documenting the recovery of native plant communities as deer populations are reduced.

Work to document life history information for deer from the Forest Preserve Districts of Cook and DuPage counties began in winter 1995. More than 130 deer have since been captured and radio-collared. Deer were monitored for survival and radio-tracked to document movements within the suburbs of Chicago. Additionally, reproductive information was collected from more than 4,000 deer removed from forest preserves during culling operations designed to reduce overabundant populations. Collection of vegetation data began in DuPage County forest preserves in 1991, two years prior to the initiation of deer culling operations. This summer will represent the ninth year for collection of this important information.

Life history information to support our model includes classic deer biology as well as unique behaviors for suburban deer. In general, suburban does are homebodies living out their lives in the same general area as their mothers. Bucks, however, are gregarious, often dispersing during their second summer. Suburban deer often existing at extremely high densities (>150 deer/mile^2) continue to have high fecundity (>1.6 offspring per adult doe) even when understory vegetation is severely depleted. Populations at these extreme densities are checked somewhat by reduced breeding

Continued on back page

Ecological Monitoring for Illinois Soils

Through several important functions, soil plays a critical role in shaping and maintaining terrestrial communities and ecosystems, whether they are natural systems, such as tallgrass prairies and floodplain forests, or highly managed systems, such as agricultural fields, orchards, and backyard lawns.

One important soil function is the harboring of a diverse community of organisms that includes bacteria, fungi, protozoa, nematodes, mites, springtails, millipedes, sowbugs, earthworms, and many others. These organisms are surprisingly abundant, with thousands of pounds, hundreds of species, and billions of individuals per acre in the top few inches of soil. This community drives the decomposition of organic residues; recycles important plant nutrients like carbon, nitrogen, and phosphorus; and contributes to the formation of new soil and soil structure. With these activities, soil organisms contribute to other important soil functions, such as supporting the growth of plants both in natural plant communities and those grown for food, fiber, or energy; and absorbing, neutralizing, and transforming compounds that might otherwise become pollutants in the environment, especially in surface and groundwater.

Photo by Ed Zaborski, INHS Center for Economic Entomology

A terrestrial isopod (Suborder Oniscoidea), about 1 cm long. Several species of isopods, living in a range of habitats, are found throughout Illinois. Common names for these animals are sowbugs, pillbugs, woodlice, slaters, and rolly-pollies.

Appreciation of the soil's importance to community and ecosystem integrity has resulted in efforts to develop methods for assessing and monitoring the condition of the soil and its functions. Assessment involves measuring soil properties at a single point in time, whereas monitoring involves making repeated measurements through time to detect changes in soil properties. In different situations, soil assessment and monitoring will serve different purposes. In highly managed production systems, such as agricultural fields, the information provided by soil monitoring and assessment can guide management decisions that help improve and sustain production in the long term while avoiding harmful environmental effects. In natural systems, the usual goal is to preserve a particular habitat or biological community. Because the balance of soil properties has a strong influence on the structure of the plant community, and thus on the above-ground community of organisms, soil monitoring can provide an early warning of changes that may lead to community or ecosystem degradation, or it may provide clues to the underlying causes of observed degradation. Similarly, soil assessment can help identify conditions in the soil that are acting as a barrier to the successful restoration of degraded communities or systems, thus providing valuable information to guide remediation and restoration efforts. Once such efforts are implemented, soil monitoring can provide the information necessary to document the progress of the project, or provide timely feedback to help refine management efforts.

In North America, several groups and agencies have been involved in developing different soil assessment and monitoring programs. For example, to address issues that affect the sustainability of forest ecosystems, the USDA Forest Service's National Forest Health Monitoring Program (http://willow.ncfes.umn.edu/fhm/fhm_hp.htm) includes measurements of soil aggregation, organic matter content, and acidity in its national forest monitoring network. INHS scientists are presently working with the Forest Service to conduct these measurements at sites in Illinois.

The Soil Quality Institute (http://www.statlab.iastate.edu/survey/SQI/sqihome.shtml) of the USDA's Natural Resource Conservation Service offers a soil quality test kit developed by the USDA Agricultural Research Service. This kit, which includes background information and guidance for interpreting results, was designed primarily for use in agricultural situations, although many of the procedures can be applied elsewhere. Similarly, the goal of the Illinois Soil Quality Initiative (a program led by Professor Michelle Wander of UIUC in collaboration with others; see Web site at: http://www.aces.uiuc.edu/~asap/isqi/isqi.html) is to identify soil quality indices that farmers can use to make management decisions within the context of their own stewardship goals.

Continued on next page

Soil Monitoring

continued from previous page

A common feature of all of these examples and others is that they emphasize physical and chemical characteristics of the soil, such as pH, bulk density, aggregate stability, and organic matter content. Those working on developing monitoring procedures recognize, however, that the important functions performed by soil result from the activities of living organisms, and that an objective, comprehensive assessment of the soil's condition should include biological measurements. To date, few biological measurements have been developed, and those included in current programs are not detailed (soil respiration or rough estimates of earthworm populations, for example).

Biological indicators offer potential advantages for monitoring and assessment of environmental conditions. Whereas precise physical and chemical measurements in the environment may be difficult or costly to perform, successful monitoring of the presence or abundance of species or groups of organisms could be accomplished with relatively little training and expense, as demonstrated in aquatic monitoring programs around the world. And unlike many physical and chemical indicators, which often reflect conditions at a specific point in time, the presence and abundance of organisms integrates information about past and present environmental conditions during the organisms' lifetimes. Also, because living organisms are sensitive to the interaction of many factors in the environment, they have the potential to indicate stresses before they manifest themselves in physical or chemical indicators, or even to indicate environmental stresses that we don't yet recognize as being important.

Because of the diversity of the soil community, ample opportunity exists to develop a comprehensive suite of biological indicators for the soil. Several hurdles must be overcome, however, before biological indicators of soil condition can be fully implemented: (1) many soil organisms have not yet been described, and easy-to-use identification keys are not widely available for many groups; (2) the development of widely applicable and standardized sampling methods, including determination of appropriate levels of sampling effort, will require targeted research efforts across a range of environments; and (3) a more complete understanding of the response of soil organisms to environmental stresses and disturbances, and of the roles of particular species or groups of soil organisms in mediating normal soil function, will make the detection of changes in populations of those organisms more meaningful by suggesting possible causes and effects associated with those changes. INHS scientists are working to address these problems to ensure that Illinois has the best tools available to manage and protect its valuable soil resources.

Photo by Ed Zaborski, INHS Center for Economic Entomology

A springtail from the superfamily Entomobryoidea. Springtails are abundant arthropods in soil and litter (up to half a million per m^2), and are related to the true insects. The specimen shown here is about 1-2 mm long.

Ed Zaborski and Chris Johns, Center for Economic Entomology

Development of an Individual-based Model to Evaluate Growth and Survival of Walleye

Walleye *(Stizostedion vitreum)* are a popular and economically important sport fish, and populations throughout Illinois are maintained through stocking (Figure 1). Recently, a seven-year research project was completed that examined the factors influencing growth and survival of introduced walleye at 14 Illinois reservoirs. These walleye were followed to determine how factors such as size at stocking, food availability, predator density, and water temperature affect growth and survival. It is especially important to understand the relationships between these factors during the first year, because walleye growth during this period is a good indicator of later survival.

To help in these efforts, we are integrating information from field data and laboratory experiments about walleye foraging, growth, and mortality into an individual-based model (IBM). Most ecological models group individual organisms into different categories (e.g., size, age, populations), consequently ignoring important individual interactions. An advantage of using an IBM is that it is capable of following individuals and identifying consequences of size-specific processes. For example, larval and juvenile walleyes are "gape limited," meaning that the size of food they can eat is limited by the size of their mouth. Likewise, predators of walleye may also be gape limited. Both foraging and predation may depend on small differences in walleye size. The model will be com-

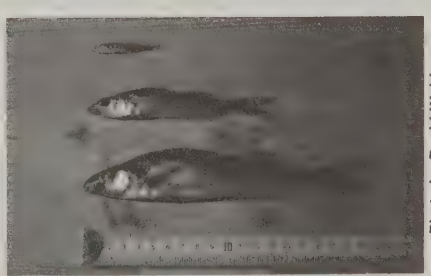

Photo by David Wahl, INHS Center for Aquatic Ecology

Figure 1. Walleye that had been introduced at different sizes in a local Illinois reservoir.

Continued on page 5

The Role of Fire in Maintaining Plant Diversity in Oak Woodland Communities

Photo by John Taft, INHS Center for Biodiversity

An experimental burn in a flatwoods near Mt. Vernon in Jefferson County.

Illinois is in an intermediate location between the predominant forests of the East and grasslands of the Great Plains. While prairies covered about 60% of the state around 1820, the vegetation was a shifting mosaic of prairie, savanna, woodland, and forest influenced in large part by the broad-scale use of fire by Native Americans. Conditions following European settlement of the region eventually favored forest development in many areas as fire frequency declined, particularly with fragmentation of the landscape by cropland and other developments. Fire-dependent communities, such as many prairie, savanna, and oak woodland habitats, began to undergo vegetational changes as oak grub sprouts and saplings became established with fire absence.

Today fire is used to maintain many prairie remnants, but it has been less frequently applied in oak woodlands. Many oak woodlands have lost much of their open savannalike structure and diverse assemblage of ground-cover species, and mesic sites appear to be converting to forests of maple and other species. While change always has been a characteristic of the prairie-forest transition zone, overall floristic diversity tends to decline when tree density (and shade) increases in these communities because a rich pool of shade-tolerant replacement species typically is lacking.

Results from research in post oak-dominated flatwoods and barrens indicate there is considerable potential for restoring diversity and stability in these habitats using prescribed fire. Flatwoods are level woodlands with slowly permeable soils, local openings, and microdepressions; they typically are seasonally moist (early spring) and dry (summer). Barrens are a type of savanna community characterized by scattered trees and a herbaceous prairie flora within generally forested regions. They typically occur on shallow soils in uplands with exposure to the south or southwest. Some flatwoods and barrens have floristic similarities; both are usually xeric habitats during much of the growing season. The harsh environmental conditions in both communities have slowed but not stopped the vegetational changes typical of the post-fire era.

Following experimental dormant-season fires in both flatwoods and barrens, ground-cover species diversity increased at all scales measured (Fig. 1). Population sizes increased for most herbaceous species and the proportion of infrequent species (prone to local extinction) declined. In a comparative study of flatwoods on the southern till plain, one site with about 20 years of annual fire prior to vegetation sampling had species diversity in sample quadrats more than four times that of unburned sites, and weedy species were absent. However, after three recent fires at another site, a sharp increase in ground-cover diversity included not only characteristic flatwoods species (e.g., numerous sedge and forb species) but also native weeds such as white snakeroot and pokeweed. These latter taxa are not typical of flatwoods; they probably reflect a grazing history and, like the new sedge species, appear to have emerged from the soil seed bank. This site is surrounded by disturbed land, including pasture, and the post-fire results may be influenced by these edge effects.

Surprisingly, in the barrens studied, prairie grasses at a fire-treatment site and a fire-free control site are in parallel decline over time despite two burns. Many studies in prairies indicate that fire increases the abundance of prairie grasses. In contrast, some panic grasses (*Panicum* spp.) typically found in open woodlands increased dramatically following each fire. The prairie grasses may be continuing a decline due to the increased shade from past forest encroachment. While the experimental fires significantly reduced the density of trees (in both barrens and flatwoods), the changes were limited to small-diameter stems and shading was not greatly re-

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Fire

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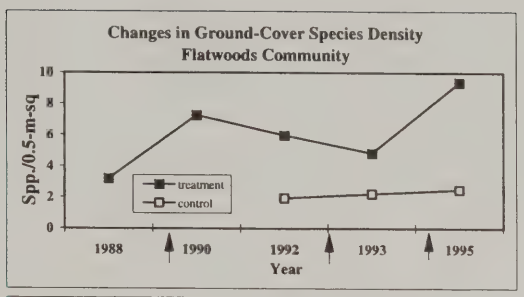


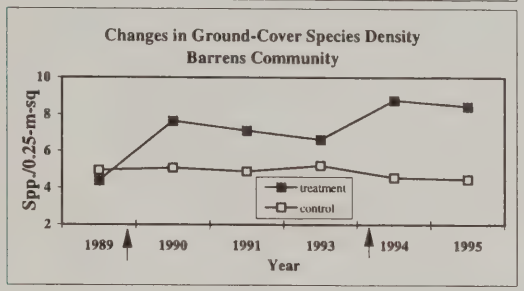


Figure 1. Changes in ground-cover species density among sample quadrats in post oak-dominated barrens and flatwoods following applications of prescribed fires. Season and year of fires are indicated by arrows (1993 burn in flatwoods was a winter burn and resulted in little response). Error bars are standard error (very small with flatwoods data).

duced. More intensive use of fire, or a combination of cutting and burning, likely will be necessary to reverse trends for prairie grasses in barrens.

While we still lack adequate data on effects of fire frequency and season on total biodiversity, the opportunity remains in the short term for the recovery of at least a portion of the diverse ground-cover characteristic of oak woodland and savanna communities. However, with continuing fire absence at most sites, vegetational changes soon may yield only depauperate and unsustainable examples of oak woodlands throughout much of the prairie-forest transition zone.

John B. Taft, Center for Biodiversity

Walleye

continued from page 3

prised of three different submodels representing foraging, growth, and mortality (Fig. 2).

The foraging submodel will determine the amount and type of food the walleye eats. Walleye undergo diet shifts as they grow that include zooplankton, benthic macroinvertebrates, and forage fish as prey. Factors such as walleye size and prey type, size, and densities driving these switches are not understood for young-of-year walleye. Currently, we are completing a series of laboratory experiments to determine how important these factors are in the walleye diets. We also have a field database of zooplankton, benthic macroinvertebrates, and forage fish information. A series of functions based on the laboratory and field data will determine foraging activity by the walleye in the model. Diet information will then be transferred to a growth submodel. A standard bioenergetics equation will be used to determine growth as the difference between energy consumed minus energy lost to metabolism and waste products. Finally, whether the fish survives will be determined in the mortality submodel. Death may be the result of thermal stress, predation, or starvation. Thermal stress occurs during the first 48 hours after stocking and is a function of walleye size and temperatures

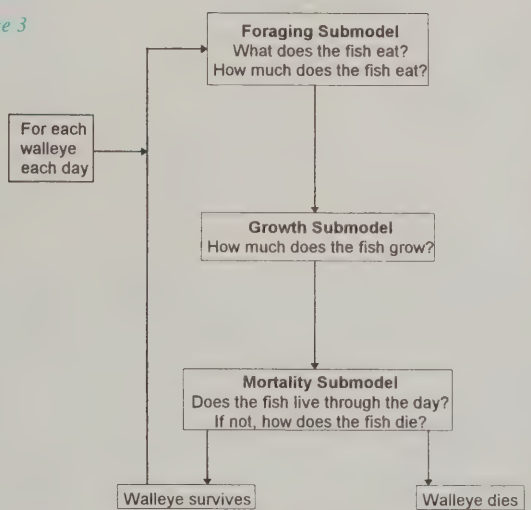


Figure 2. Schematic of the submodels used in the walleye individual-based model.

of the hatchery and reservoir. Alternatively, the walleye could die from predation or cannibalism. Ongoing population estimates and diet analyses of predators like largemouth bass *(Micropterus salmoides)* will allow development of mortality relationships as a function of predator density and size structure. Cannibalism rates will also be determined from field collections of walleye. Finally, walleye may die of starvation determined by each fish's feeding history and condition in the foraging and growth submodels.

By including factors such as size at stocking, water temperature, thermal stress, predation pressure, and food availability, we will be better able to predict growth and survival of stocked walleye. By integrating laboratory and field data, we are building a database about walleye and identifying knowledge gaps. This IBM will eventually be applied to other systems with different temperatures, walleye sizes, predation pressure, and prey resources from within and outside Illinois. The model may ultimately also be modified to include effects of natural reproduction, different stocking practices, and habitat availability. With this model, fishery managers will be better able to predict future walleye population structures with important ecological and economic implications.

Tracy Galarowicz, David H. Wahl, and Bob Herendeen, Center for Aquatic Ecology

Species Spotlight

Orange-throat Darter

Susan Post

The Family Percidae contains both darters and perches. While the larger members of the order—walleye, sauger, and yellow perch—are familiar, the majority of the species, the darters, are too small to be known by many people. Most darters are less than four inches long. Among North American freshwater fishes, however, the darters are second only to minnows in numbers of species and abundance. Due to the loss of the swim or gas bladder, darters dart about the stream bottom; hence, their name. Many species (especially the males) are brightly colored. The orangethroat darter, *Etheostoma spectabile*, is perhaps one of Illinois' most notable examples.

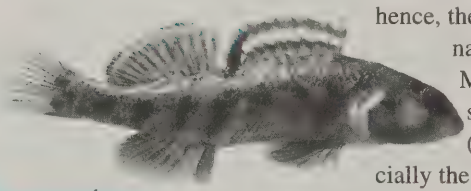


Photo by Larry Page, INHS Center for Biodiversity

The orangethroat darter. *Etheostoma spectabile.*

The orangethroat darter is approximately three inches in length. The breeding male has alternating brick red and metallic blue-green bars on the side of the body, bright blue and orange-red bands through the first dorsal fin, and a bright blue-green anal fin. Its bright orange throat provides the common name. The female is a dull, neutral olive with tinges of blue and orange.

Riffles and pools of small streams that have mixed sand and gravel bottoms are the preferred habitat of the orangethroat darter. This darter occurs throughout the state and is often a pioneering species. It soon reoccupies formerly dry streambeds and will ascend well into the headwaters. Larval insects such as blackflies and caddisflies, bloodworms, and fish eggs make up the majority of its diet.

Spawning usually occurs in March and April. The colorful male migrates to the shallow gravel riffles (breeding riffles) in late March. The female spends most of her time in pools at the base of the riffles. The female swims into a riffle, where she is followed by several males. One male attempts to keep the others away by making short dashes at them with its fins erect. The female is closely followed by the male until she wiggles into the gravel. This is the signal that the female is ready to lay her eggs. The female forces her head into the gravel while in an almost vertical position and then moves into a horizontal position with the lower half of her body buried. This stimulates the male to mount. The pair then vibrates rapidly. Three to seven eggs are released, fertilized by the male, and buried in the gravel. The female moves forward on the riffle and spawns several more times, either with this male or another one.

Once the adults have spawned, they leave the fine gravel riffles for deeper rocky pools. The eggs hatch in about 10 days and the young grow quickly. They are usually found scattered over gravel near the adults and are almost adult size by fall.

Teacher's Guide to "The Naturalist's Apprentice" (facing page)

So Many Fishes! How Can You Tell Them Apart?

Objective: to make students aware that there are many species of fish in Illinois, and to introduce students to the dichotomous key.

Materials needed: a copy of **"So Many Fishes! How Can You Tell Them Apart?"** and a copy of "Fish Anatomy" for each student.

Other ideas: Before handing out the key to students, have them distinguish several classroom objects by use of a simple key. Example: book, pencil, chalkboard eraser, chalk, box of pencils.

1. a) object has square or rectangular shape with corners — Go to 2
   b) object not as above (cylindrical or round)—Go to 3

2. a) object cannot be opened and has soft, porous surface—eraser
   b) object can be opened—Go to 4

3. a) object flat on both ends, has no core—chalk
   b) object comes to point on end, has a central core of dark material—pencil

4. a) object has several paper sheets between hard covers—book
   b) object not as above—box of pencils

Have the students make a key of their own to distinguish five or six other objects in the classroom. Remind them that the statements in the key only need to distinguish the object or objects from the other objects, and only those that have not yet been eliminated. A key must be followed from the first couplet for each object. Notice that the couplets 2 and 9 in the fish key are identical. If couplet 1 had been skipped, then couplet 9 would incorrectly identify the channel catfish and tadpole madtom.

Answers:

a) blackspotted topminnow
b) brook stickelback
c) quillback
d) spotfin shiner
e) tadpole madtom
f) blue gill
g) channel catfish
h) orangethroat darter
i) black redhorse
j) blackside darter

The Naturalist's Apprentice

So Many Fishes! How Can You Tell Them Apart?

Carolyn Nixon

There are more species of fish in Illinois than any other group of vertebrates (animals with backbones) except birds. Currently, there are 194 (179 native and 15 introduced) species of fish living and reproducing in the lakes, ponds, streams, rivers, and backwaters around the state. Have you ever wondered how ichthyologists (scientists who study fish) are able to tell one species from another? While some are distinct, many more are difficult to tell apart. Scientists use a tool known as a dichotomous key to identify different unfamiliar plants or animals. These keys are written by other scientists (experts on the particular group of organisms) as an aide to others who have a need to identify plants and animals.

A dichotomous key is a series of paired opposite statements (couplets). The scientist will read the first statement in the couplet that describes some characteristic of that organism. If the statement is true, then the scientist will follow the directions given after that statement. If the statement does not fit the organism, the scientist will read the second statement in the couplet. If the first statement did not match the organism, the second statement should. As the scientist works through the key, he or she will either identify the organism or continue to another couplet. By following the directions given at the end of each statement that most closely matches the description of the unknown organism, the plant or animal can ultimately be identified.

Below are pictures of 10 Illinois fish. See if you can identify them using this simple key.

1. a) Whiskerlike barbels present on head (catfishes)—Go to 2
   b) No whiskerlike barbels present on head—Go to 3

2. a) Caudal fin forked—channel catfish
   b) Caudal fin rounded—tadpole madtom

3. a) Mouth facing downward (suckers)—Go to 4
   b) Mouth not facing downward—Go to 5

4. a) Front edge of dorsal fin at least 4 times longer than back edge—quillback
   b) Front edge of dorsal fin less than 4 times longer than back edge—black redhorse

5. a) Body elongate, more than twice as long as tall—Go to 6
   b) Body not elongate, but slab-sided. Not more than twice as long as tall—bluegill

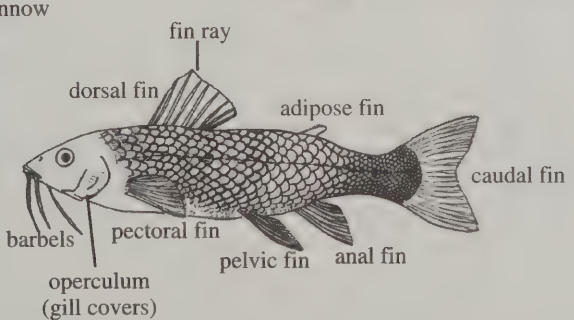
6. a) First five rays of dorsal fin spikelike—brook stickelback
   b) First five rays of dorsal fin not spikelike—Go to 7

7. a) Two dorsal fins. (darters)—Go to 8
   b) Only one dorsal fin—Go to 9

8. a) Bold irregular black stripe on side, like a series of connected blotches—blackside darter
   b) No bold black markings on side. Markings are narrow vertical bars—orangethroat darter

9. a) Caudal fin forked—spotfin shiner
   b) Caudal fin rounded—blackspotted topminnow

All drawings above taken from P.W. Smith (1979), *The Fishes of Illinois*.



Fish Anatomy
Drawing by Carolyn Nixon, INHS Center for Economic Entomology

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Urban Deer

continued from front page

by younger does and by higher fawn mortality.

Overall survival for adults is greater than 80% annually, which is similar to survival reported for deer living on refuges in the Midwest. As might be expected, auto-deer and train-deer collisions account for more than 60% of annual deer mortalities with a few hunting and poaching losses accounting for the remainder. Unlike elsewhere in Illinois spring, not fall, is the time of year when most suburban deer are killed by cars. We have also documented a potential adaptive strategy used by suburban deer to cross roads during heavy rush-hour traffic. Adult deer will patiently watch cars drive by and wait for a lull in traffic when they can sprint across untouched. Considering the high reproductive potential and high survival of suburban deer, it's easy to see how this species continues to thrive even in the potentially harsh suburban environment.

Photo by Dwayne Etter, University of Illinois

White-tailed deer, a common site in Chicago suburbs.

Results from the vegetation study are encouraging for the recovery of ecosystems heavily impacted by overabundant deer. In most cases we have observed an increase in native plant species composition, plant height, and overall ground cover as deer populations have been reduced from more than 100 deer/mile^2 to less than 40 deer/mile^2. We have also documented the appearance and resurgence of several rare native plant species in forest preserves where deer populations have been greatly reduced. Some notable species include Michigan lily, upland boneset, and great flowering trillium.

This research will assist managers from the Chicago region and potentially nationwide in better managing overabundant suburban deer, restoring depressed native ecosystems, and reducing human-deer conflicts.

Dwayne R. Etter, Department of Natural Resources and Environmental Sciences, University of Illinois, and Timothy Van Deelen, Center for Wildlife Ecology.

ILLINOIS NATURAL HISTORY SURVEY

Reports

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

July/
August 1999
No. 358

INSIDE

Readers' Contest With a Serious Scientific Purpose

Readers of the recent issue of the *Illinois Natural History Survey Reports* devoted to invasive species in Illinois (No. 354, November /December 1998) will be familiar with the story of the detection in 1998 of the Asian longhorned beetle (*Anoplophora glabripennis*) in Cook and DuPage counties. Entomologists at the Illinois Natural History Survey are, of course, interested in determining if this very destructive beetle has become established elsewhere in Illinois. Along this line, the Survey is offering a free copy of the Survey's Manual 6, *Field Guide to Northeastern Longhorned Beetles* by Douglas Yanega, to the first reader to submit a specimen of the Asian longhorned beetle from any Illinois county where the beetle has not been detected previously.

Hint: Search for the beetle on the trunks and limbs of its host trees such as maples, boxelders, willows, poplars, elms, locusts, and mulberries, among others. These beetles are about 1 inch long and shiny black with white spots. They are difficult to spot in the dappled shade of trees.

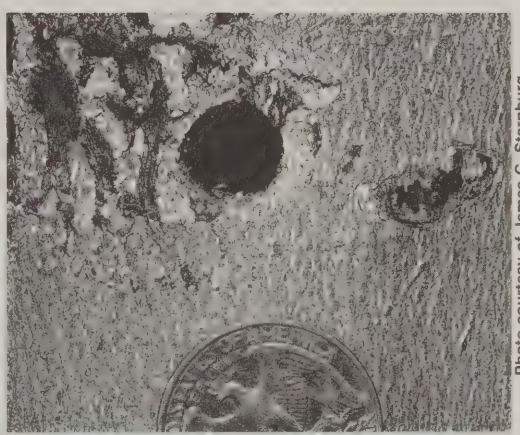


Photo courtesy of James G. Sternburg

Exit hole in tree chewed by emerging beetle.

Photo by Phil Nixon, INHS Center for Economic Entomology

Feeding damage caused by Asian longhorned beetle larvae.

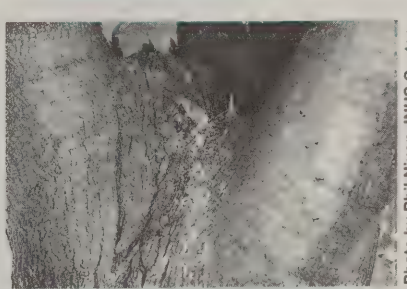


Photo by Phil Nixon, INHS Center for Economic Entomology

Sawdust accumulation in tree crevice caused by feeding of Asian longhorned beetle larvae.

Photo courtesy of James G. Sternburg

An adult Asian longhorned beetle.

Specimens should be submitted either dry and carefully wrapped, or in a small bottle filled with rubbing alcohol. Please include details of the locality and date of collection and send specimens to (don't forget to provide a return address so we can mail the field guide to you if you are the first person to send a beetle from your county—excluding Cook and DuPage counties):

John K. Bouseman
Illinois Natural
History Survey
607 E. Peabody Dr.
Champaign, IL 61820

John K. Bouseman, Center for Economic Entomology

Bird Migration: How Much Fuel Does a Songbird Need?

Scientists at the Illinois Natural History Survey pioneered research on migration using tiny radio transmitters attached to birds during natural flight. Tracking the birds is accomplished by driving beneath them in a vehicle fitted with special electronic equipment and chasing as long as possible. Because most migration takes place high above the ground at night, radio tracking is one of the few ways of learning about this critical phase in the life of birds. A new use of this method promises to help conservation of migrating songbirds.

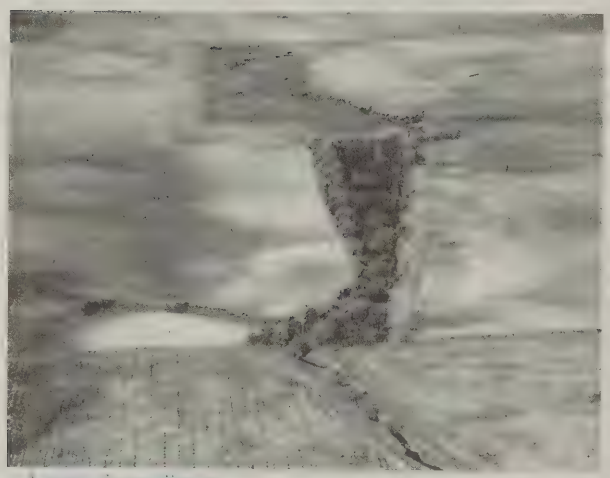


Photo by Phil Mankin, University of Illinois

A typical woodlot in east-central Illinois where Survey researchers captured, measured, and released radio-tracked birds.

Birds migrating through Illinois require the right habitat for daytime stopovers. In particular, they need fuel—a rich food supply to support the energetic demands of long migratory flights. For the majority of forest-breeding birds this means wooded habitat, which is scarce in both urban areas and the rich agricultural areas covering much of Illinois. We do not know whether migrating birds actually suffer because they have trouble finding suitable wooded areas for stopover or because they are packed in too densely, but we do know that wooded areas swarm with hungry birds during migration.

Are woodland "gas stations" in Illinois up to the job of providing fuel for millions of migrating songbirds during a few weeks in spring and fall? To answer the question one needs to know not only the quantity and quality of fuel available and the number and sizes of birds needing it, but also the mileage attained by birds flying long distances at night. Flight efficiency during migration is presently estimated using simple aerodynamic theories of how birds fly (assuming they are like little aircraft) and measurements of metabolism of birds on short flights and confined in wind tunnels.

To get substantial data on this subject, a team of researchers in the Center for Wildlife Ecology is combining radio tracking with an isotopically labeled water technique on freely migrating birds. Researchers catch a migrant bird while it is feeding in a wooded area, inject it with a tiny quantity of an inert but detectable water isotope, and attach a radio transmitter. Then they follow the bird's transmitter wherever it flies, all night if necessary, and recapture the bird as soon as possible to determine the energy used in the flight by analyzing the water isotope. The work is being done in collaboration with scientists at the University of Illinois and in the Netherlands. The results should help us evaluate and manage remaining forested areas in Illinois so they can support birds that depend on them.

During planning, the researchers had to explain that they were basing an entire research project on being able to follow a 1-ounce migrating bird anywhere it decided to fly and then catching that same bird again right away. Although no one said, "You plan to WHAT?," there were many polite smiles and vague wishes of good luck. Fortunately, followed by two vehicles and an occasional radio-tracking aircraft, many birds are cooperating. One recent thrush plopped softly into a net in a patch of forest 40 minutes after sunrise, none the worse for wear, its radio transmitter beeping steadily.

If you are a property owner, tired scientists may knock on your door early one morning in the fall or spring explaining that an important small bird has chosen your land for stopover habitat. They will catch the bird, peel off its little transmitter, take a drop of blood from a pinprick, and release the bird to fuel up and continue its migratory journey. Be understanding, and be proud that you are providing an essential resting and refueling place for insect-eating migrating birds!

Martin Wikelski, Ronald P. Larkin, Arlo Raim, Philip Mankin, Robert H. Diehl, Center for Wildlife Ecology

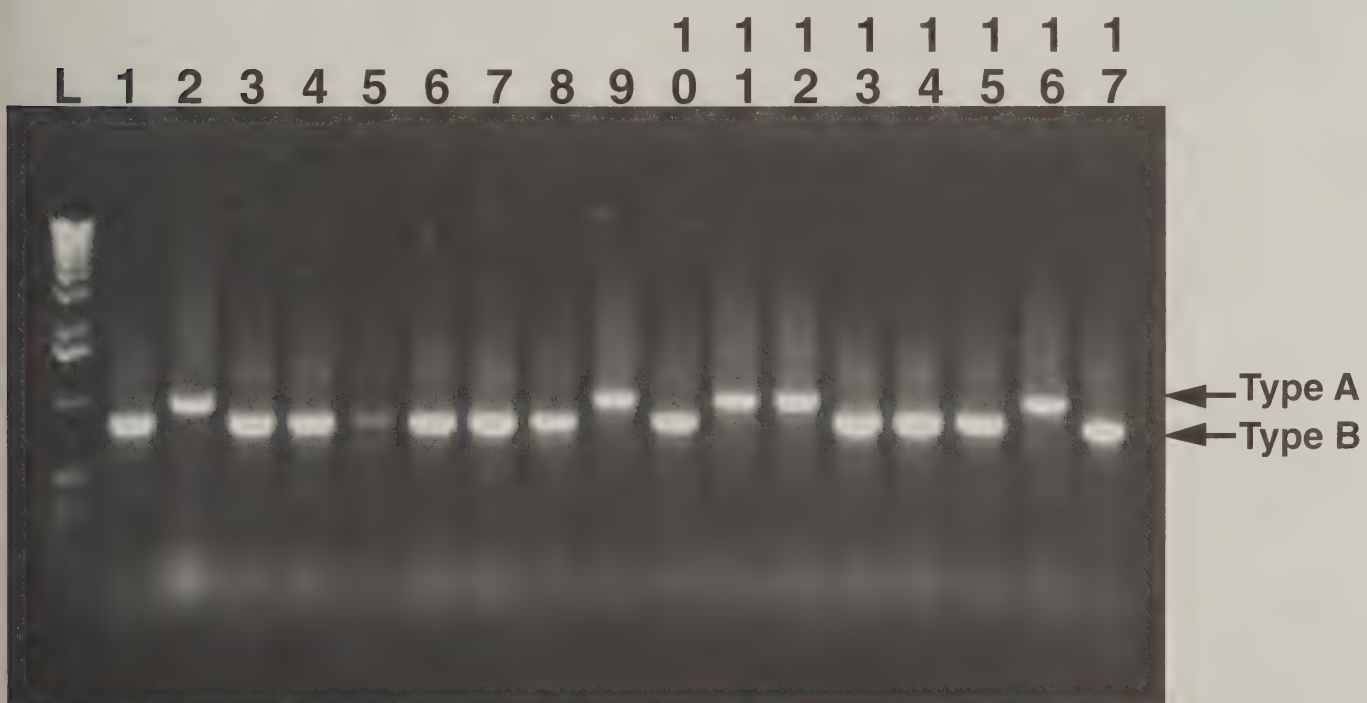
A New Form of an Old Soybean Pathogen

Soybean brown stem rot is a disease caused by the fungal pathogen *Phialophora gregata*. The disease was first discovered in Illinois in 1949. Now the disease is found in many soybean production areas including the midwestern U.S., Brazil, Egypt, and Japan. In Illinois, the disease is one of the major soybean diseases in the northern two-thirds of the state. The disease could cause up to 30% yield loss if conditions were right.

Soybean cultivars resistant to brown stem rot have been used to control the disease in the past 15 years. However, in recent years, more and more disease incidents of brown stem rot have been observed in the resistant soybean cultivars. Scientists at the Natural History Survey in cooperation with plant pathologists in Illinois and Wisconsin are investigating the emerging population of the pathogen that causes brown stem rot on the previously resistant soybean cultivars. A new form (type B) of the old soybean pathogen has been identified. This new form of the pathogen can be identified by several DNA markers that can unambiguously separate the new form from the traditional form (type A) of the pathogen. The scientists have developed a robust and quick test to identify and differentiate the two genotypes of the pathogen (see figure). This new form of the pathogen is widespread and has been observed in seven midwestern states.

Field studies have shown that the new form of the pathogen is mostly isolated from soybean cultivars like Bell and S282N, which are resistant to brown stem rot, whereas the old forms of the pathogen are primarily isolated from soybean cultivars like Sturdy and Pioneer 9305 that are susceptible to the disease. Discovering the new form of the pathogen is a significant breakthrough in our understanding of the widespread high-disease incidents among previously resistant soybean cultivars. The discovery provides a new target for breeding future resistant soybean cultivars. It also provides a means to study and understand the host-specific infection by the brown stem rot pathogen in order to develop efficient control strategies and to increase soybean yields for Illinois agriculture.

Weidong Chen, Center for Biodiversity



A robust test showing the genotypes of the soybean brown stem rot pathogen (*Phialophora gregata*) and separating the new form (type B) from the traditional form (type A). **Photo by Weidong Chen, INHS Center for Biodiversity**

Quality Management of Bluegill Populations: Understanding Factors Affecting Population Size Structure

The bluegill (*Lepomis macrochirus*) is an important target sport fish throughout North America, with annual harvest rates for this species often surpassing all other sport fish combined. In Illinois reservoirs, fisheries managers and ecologists are faced with conservation issues that may be associated with high rates of harvest; some bluegill populations contain only small fish. These "stunted" populations produce males that rarely exceed six inches in total length, which is in sharp contrast to "quality" bluegill populations that consistently produce males eight inches or greater. Management efforts to increase the size structure of bluegill populations are often unsuccessful because managers have failed to address factors that determine the ultimate size bluegill attain in these populations. The focus of our research involves investigating these factors and determining appropriate management strategies to alleviate stunted bluegill populations.

Photo by David Philipp, INHS Center for Aquatic Ecology

A bluegill, *Lepomis macrochirus*.

Four components of growth determine the ultimate size of a fish: juvenile growth rates, age-at-maturation, adult growth rates, and longevity. Factors affecting any one of these four components can cause changes in the size a fish attains. Traditional management practices have focused on density-dependent factors related to growth rates (i.e., too many small bluegill and limited food resources causes decreased growth and smaller ultimate sizes). Although density-dependent processes may affect bluegill during each life stage, management efforts to alleviate stunting based on this mechanism alone fail to address key principles of bluegill life history. Data comparing life histories among populations of bluegill across Illinois indicate that age-at-maturation is a critical determining factor.

Bluegill are colonial spawners, and males compete for the best nest sites within these colonies. Because nests that are centrally located within colonies provide the best protection against egg predators (that must enter the colony from the periphery), females spawn preferentially with males in these central nests. Male-male competition for these premium locations is intense, and larger males are better competitors. To be competitive with large, dominant males, smaller, less competitive males are forced to delay maturation and grow for an additional year. If, however, large males are removed from nests via recreational angling practices (which often target these large, bright, aggressive males), younger, smaller males stop growing to become reproductively mature and successfully compete for spawning opportunities. This change in life history results in stunted populations; not because of slow growth, but because of early maturation.

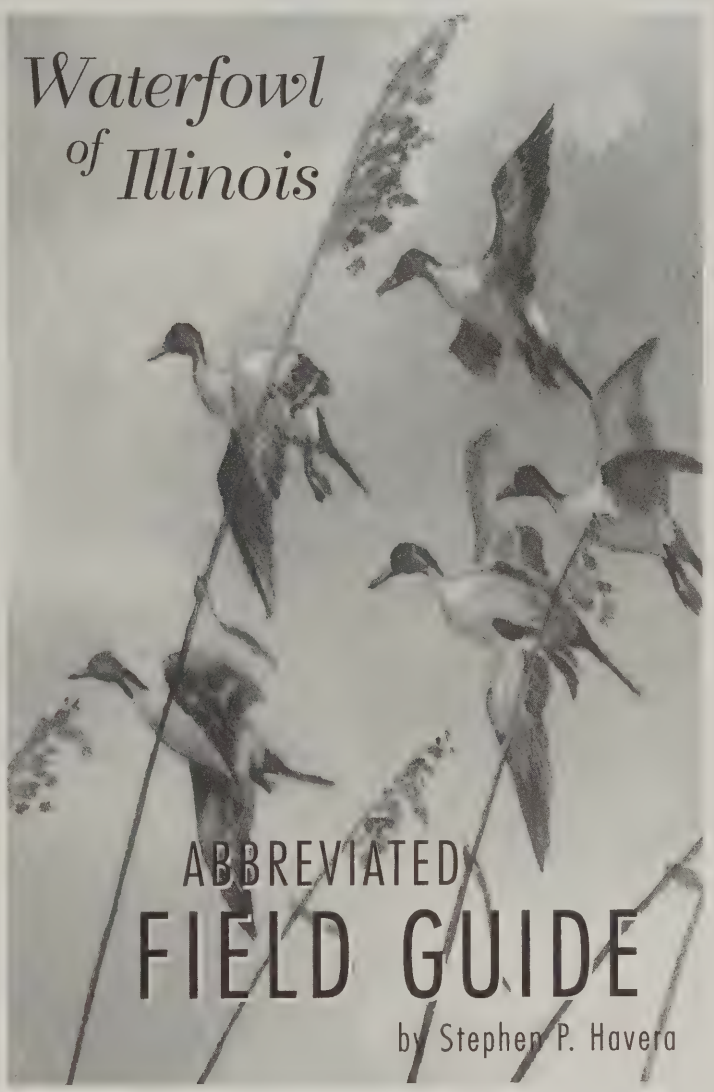
Experimental management efforts on 32 state impoundments are focusing on identifying management practices that can best increase age-at-maturation of stunted populations. These management initiatives combine traditional approaches (thinning juvenile bluegill populations) with components designed to maximize the number of larger adults in an effort to suppress early maturation of marginally competitive juveniles. Specifically, our current study tests harvest regulations (8-inch minimum size limit/10 fish daily bag) and predator (largemouth bass) additions, separately and in combination, in a variety of reservoirs throughout the state. This investigation will test the effectiveness of management strategies aimed at addressing components of bluegill reproductive ecology not previously considered in traditional management practices. We believe that this comprehensive approach, which addresses age-at-maturation, will achieve better success at increasing size-structure of bluegill populations than traditional approaches based solely on growth rates.

Derek Aday, John Hoxmeier, Julie Claussen, David Wahl, and David Philipp, Center for Aquatic Ecology

New INHS Publications

Waterfowl of Illinois: Status and Management (and *Abbreviated Field Guide)*

INHS Special Publication 21 and INHS Manual 7



The INHS Publications Office is currently producing a two-volume set of the waterfowl of Illinois. The first volume (Special Publication 21) is a comprehensive hardbound treatise covering the history and status of waterfowl in Illinois from the 1800s to the present. The second accompanying volume (INHS Manual 7) is an abbreviated field guide of Illinois waterfowl. This 80-page softbound book is designed to be taken into the field for easy identification of the waterfowl living throughout the state. These books may be purchased separately or as a set. Please see end of article on page 7 for ordering information and date of availability.

Background

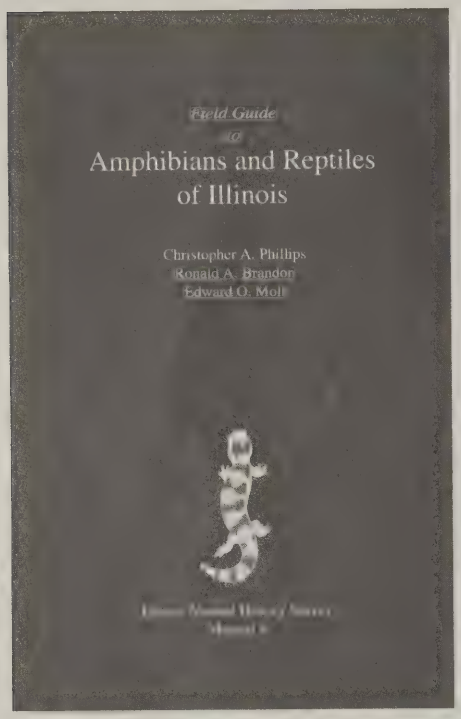
Illinois lies in the heart of the Mississippi Flyway with waterfowl breeding grounds to the north and the wintering grounds to the south. Because of the high quality and abundance of its wetlands, Illinois has historically welcomed legions of nesting and migratory waterfowl and other waterbirds. The prairies prevalent in east-central Illinois prior to European settlement were rich in wetlands. The renowned Winnebago Swamp, Kankakee Marsh, northeastern glacial marshes, and baldcypress-tupelo gum swamps in the southern tip of the state were remarkable wetlands that complemented the luxurious bottomlands of the river floodplains.

A strong and colorful waterfowl tradition emerged in the Prairie State, particularly along the Illinois and Mississippi rivers. Private duck clubs were established in the late 1800s, some of which remain in operation today. Market hunters found abundant supplies of waterfowl that were shipped to restaurants throughout the eastern United States. Carvers of wooden decoys and the makers of duck calls embellished the Illinois waterfowl tradition. The first large-scale trapping of waterfowl in the United States took place near Browning on the Illinois River in 1922. Few other states have such a rich history and depth of waterfowl information.

Although its landscapes have changed dramatically in the past two centuries, Illinois still hosts significant numbers of waterfowl and other waterbirds, especially during fall and spring migrations, and will continue to do so. There is an indescribable lure about waterfowl that captures our interest, whether we are birdwatchers, conservationists, outdoor enthusiasts, or hunters. We want to know what kinds of waterfowl frequent our state, when, where, how many, what they eat, where they nest, and what we can do to enjoy or help them.

Continued on page 7

Amphibians and Reptiles of Illinois—INHS Manual 8



A field guide to aid biologists, naturalists, land managers, law enforcement officials, and students in the identification of the amphibians and reptiles found in Illinois. Full-color photographs of all 102 species plus information on habitats, natural history, and distribution.

$19.95
hardcover
PROVISIONAL PRICE
300 pages

ORDERING INFORMATION

To order **Field Guide to Amphibians and Reptiles of Illinois**, *please call 217-333-6880; e-mail order to cwarwick@mail.inhs.uiuc.edu; or write to Illinois Natural History Survey, Distribution Office, 607 E. Peabody Drive, Champaign, IL 61820. Books will be available to ship in August 1999.*

Milk snake — Colubridae

Lampropeltis triangulum

Key Characters: Black-bordered red or brown blotches or rings; belly white with sharply contrasting black spots; back scales smooth; anal plate not divided.

Similar Species: Prairie kingsnake, Great Plains rat snake.

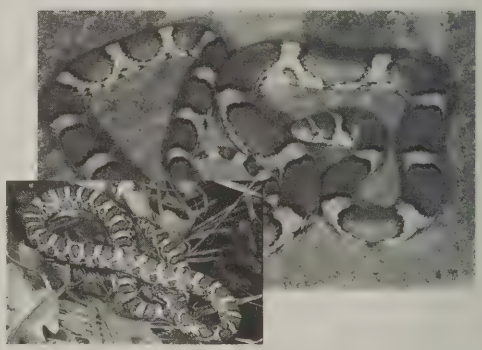
Subspecies: Eastern milk snake, *L. t. triangulum*; red milk snake, *L. t. syspila*.

Description: Medium-sized (up to 110 cm TL) snake with variable color pattern. The less brightly colored *L. t. triangulum* has 33–46 brown blotches on the back alternating with 1–2 rows of spots on the side. The brighter *L. t. syspila* has 19–26 red blotches on the back and 4–8 red rings on the tail.

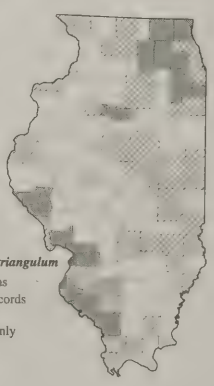
Habitat: A variety of habitats from rocky, wooded hillsides and glades to old fields and wetlands.

Natural History: Usually found in rotting logs, under bark of stumps, or under logs, rocks, and other surface debris. Mates in spring and lays 8–20 eggs in June in rotting logs, tree stumps, or other rotting vegetation. The young hatch in August or early September at 20-25 cm TL. Diet includes small mammals, birds and bird eggs, reptiles and reptile eggs, frogs, and fish. Predators include birds of prey and mammals, but many more probably are killed on roads by vehicles.

Status: Not commonly seen, except perhaps in the Chicago region and portions of the Shawnee Hills, because of its secretive nature. Red milk snakes may be over-collected for the pet trade at some localities.

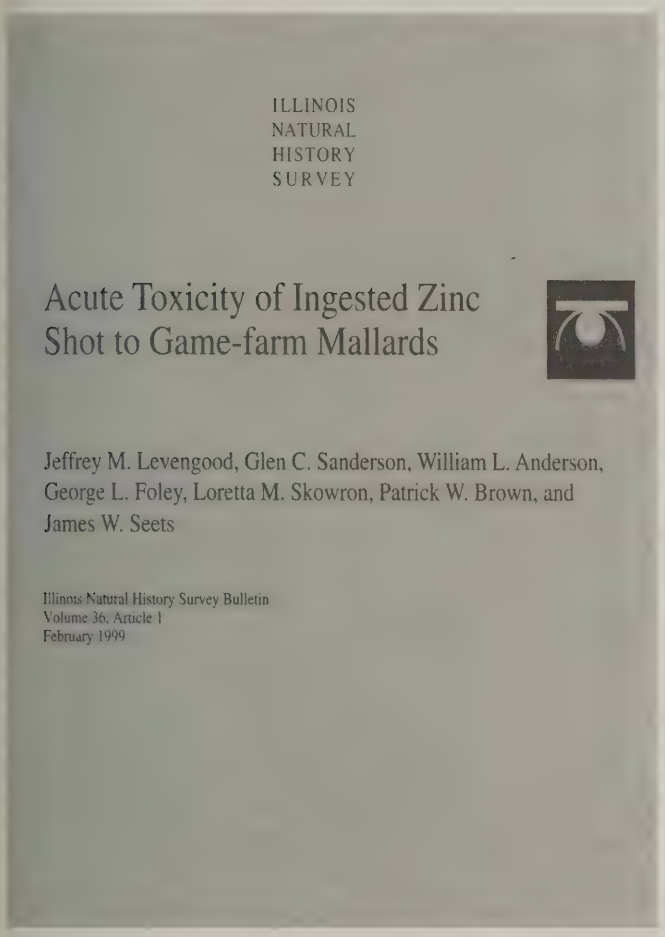


Milk snake (*Lampropeltis triangulum syspila*), Monroe Co., IL. (MR)
(Inset) *Lampropeltis t. triangulum*, Cook Co., IL. (MR)



Distribution of *Lampropeltis triangulum*
Purple = vouchered specimens
Light blue = photographic records
Yellow = verified sighting
Slanted = pre-1980 records only

Acute Toxicity of Ingested Zinc Shot to Game-farm Mallards—INHS Bulletin 36(1)



A peer-reviewed scientific publication of a study of the toxic effects of zinc shot ingested by game-farm Mallards. INHS Bulletin 36(1) is the most recent publication in our prestigious Bulletin series, which has been continuously published since 1876.

This bulletin may be purchased for $10 per copy by sending a personal check or money order made out to the Illinois Natural History Survey (INHS) to the following address:

INHS Distribution Office
607 E. Peabody Dr.
Champaign, IL 61820
(217) 333-6880.

A free publications catalog listing all publications currently in stock is available upon request at the telephone number above. The catalog may also be accessed on the Web at URL: http://www.inhs.uiuc.edu/chf/pub/pub-catalog/spring98/index98.html

Waterfowl of Illinois

continued from page 5

From 1980 through the mid-1990s, the data included in *The Waterfowl of Illinois* were gathered and summarized to complete a picture of waterfowl biology and history of this region of the Midwest. Because of the longevity of the Illinois Natural History Survey (established in 1857) and its waterfowl program (begun in 1938), the strong heritage of waterfowl in the region, and the importance of the Illinois and Mississippi rivers, a compendium of this waterfowl knowledge was essential.

These books focus on Illinois and include a flavor of the history of waterfowl intermingled with biology and management. The work summarizes more than a century of waterfowl information and provides a library of references, a wealth of figures and color photographs, and a brain trust of facts. Chapter subjects include waterfowl populations and their distributions, habitat, food habits, hunting traditions, harvest, banding, management, nesting, the history of Canada Geese, and the biographies of some of the biologists who advanced the knowledge of waterfowl in the twentieth century. The information presented in this endeavor will be of interest to those who appreciate the wetlands and the waterbirds they sustain in the Mississippi Flyway. The abbreviated field guide makes available selected highlights from its companion volume.

Both books are available for $69.95, or the book separately for $59.95 and the field guide for $14.95. Prices include shipping. *The Waterfowl of Illinois* is expected to be ready for shipping in August 1999. To order contact Katie Roat or Stephen Havera by phone at 309-543-3950; by mail—Waterfowl Book, Illinois Natural History Survey, P.O. Box 590, Havana, Illinois; or e-mail: shavera@mail.inhs.uiuc.edu

Stephen P. Havera, Center for Wildlife Ecology

ILLINOIS
NATURAL
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ILLINOIS NATURAL HISTORY SURVEY

Reports

September/
October 1999
No. 359

INSIDE

Turkeys on the Edge of the Prairie

Because of habitat loss and unregulated hunting, wild turkeys (*Meleagris gallopavo*) were extirpated from Illinois by the early 1900s. However, successful restoration has demonstrated the adaptability of these birds. Once thought to require extensive tracts of forest, turkeys now exist in areas of the Midwest with less than 20% forest cover. Restoration in Illinois, which began in 1959, has now been so successful that reestablished turkey populations exist in nearly all 102 counties. Of these, 81 counties are open to turkey hunting. However, despite successful reestablishment and apparently good habitat, turkey populations remain low in some areas.

Photo by James Seets, INHS Center for Wildlife Ecology

Patrick Hubert releasing Wild Turkey after capture and radio tagging.

Previous research has shown that turkey populations are sensitive to variation in hen survival, nest success, and poult survival, and that these factors may fluctuate widely between years. However, much of this research was conducted in other parts of the Midwest with more forest cover or a lower percentage of row crop (corn and soybean) cover or both. Managers in Illinois need information on the effects of Illinois' mix of agriculture and forest on turkey population performance to better manage prairie state turkey populations.

With this need in mind, the Illinois Department of Natural Resources (IDNR), Federal Aid in Fish and Wildlife Restoration, the National Wild Turkey Federation, and the Illinois Chapter of the National Wild Turkey Federation provided funds to allow researchers at the Illinois Natural History Survey to study wild turkey ecology at the interface of agriculture and forest in Illinois. For this study, we selected Cass County in west-central Illinois and Clark County in southeastern Illinois. Despite similar release histories, county size, and similarities in gross habitat characteristics, Cass County supports a larger turkey population than Clark County.

We began capturing turkeys using rocket-nets during the winter of 1997-1998. Since then we have captured 101 turkeys and radio-tagged 76 hens. We are monitoring radio-tagged hens to determine survival, nest success, poult survival, range size, and habitat use. We are also taking data on body condition, causes of mortality, and vegetation characteristics at nest sites.

Annual survival of hens has been similar in the two counties but below 50%. Most deaths have been related to predation, with coyotes suspected as the major predator. Other sources of mortality include poaching and

Continued on back page

Education Outreach at the Survey: Bringing Science to the People

Photo by Joel Dexter, Illinois State Geological Survey

The Education Outreach Program of the Illinois Natural History Survey is varied, diverse, and ever-changing.

Philosophically, outreach at the Survey is centered around one simple statement written by Stephen A. Forbes in 1891: "The children [and adults!] must be drawn towards and not away from the woods and fields and waters and must be led to see more clearly . . ." On any given day, outreach is:

• designing, constructing, and staffing a major exhibit about Illinois—Chicago Sportsmen's Show, McCormick Place

Photo by Carolyn Nixon, INHS Office of the Chief

Photo by Carolyn Nixon, INHS Office of the Chief

• piquing the interest of middle school girls in science —Girls in Engineering, Math, and Science (GEMS) Program

Photo by Michael Jeffords, INHS Center for Economic Entomology

• building and staffing a booth about Illinois organisms—Allerton Park Chautauqua

Photo by Michael Jeffords, INHS Center for Economic Entomology

• training Illinois citizens in the rigors of ecological monitoring—Illinois EcoWatch Program

Photo by Carolyn Nixon, INHS Office of the Chief

• developing innovative ways to teach everyone about the world of insects—Insect Theatre

Photo by Michael Jeffords, INHS Center for Economic Entomology

• training teachers about biodiversity, wetlands, and biological control—Purple Loosestrife Education Program

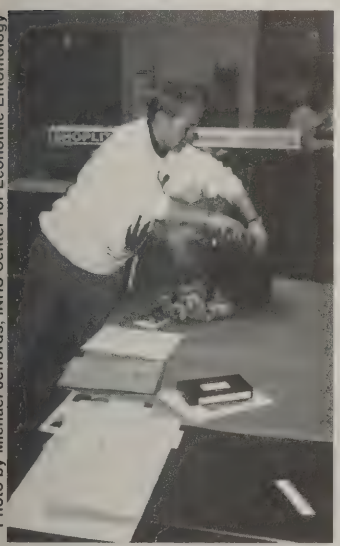


Photo by Michael Jeffords, INHS Center for Economic Entomology

• conducting nature workshops throughout the state for educational institutions and government agencies

Photo by Michael Jeffords, INHS Center for Economic Entomology

• putting children in intimate contact with a wetland

Photo by Susan Post, INHS Center for Economic Entomology

• helping inner-city children plant a prairie in a vacant lot near Cabrini Green in Chicago—Community Youth Creative Learning Experience (CYCLE) Program

Looking Before We Leap: All in a Day's Work at INHS

Ever since we were all babes in the woods (figuratively and literally), we have been taught to look before we leap. Our authority figures tried to instill the notion that a little planning and careful attention to where we were going next, whether on a long odyssey or a simple jaunt in the forests near our homes, were a prudent investment in the future. There was no telling what was on the other side of those logs we were ready to hop, so it made good sense to look before we leapt and trod on something hiding there.

Even governmental agencies have learned this lesson and in many cases have institutionalized the looking-before-leaping process. For instance, the Illinois Department of Transportation (IDOT), which is responsible for upgrading and maintaining the state's highway system, is required to make biological assessments of areas where it plans to make or replace roads. Before it leaps into construction activities, IDOT must look to determine how such construction will impact the plants and animals in the surrounding environment. Actually, IDOT contracts the Illinois Natural History Survey (INHS) to do the looking.

INHS field biologist Bill Handel, who specializes in endangered species and grading natural communities, has served as the eyes for IDOT and its construction of Illinois Route 20 that traverses the state from Chicago in the east to Dubuque, Iowa, in the west. As co-principal investigator in the biological assessment of Route 20, Handel and his colleagues in the Statewide Biological Assessment Program and the INHS Wetlands Group have studied some 70,000 acres (109 square miles) along this highway since 1993. These researchers have discovered a number of unrecorded threatened and endangered plants and animals as well as high-quality natural communities. Some of these rare species reside in Tapley Woods Natural Area, a holding of INHS' parent organization, the Illinois Department of Natural Resources.

The new knowledge uncovered by INHS scientists will be very useful to IDOT as it proceeds with construction along Route 20. IDOT can now take measures to minimize the potential negative influences of construction upon the plants and animals along this highway

Photo by William Handel, INHS Center for Biodiversity

A timber rattler exiting a food cooler.

Occasionally Handel and the staff of the Statewide Biological Assessment Program, in their role of being the eyes for IDOT, get unsolicited help from concerned citizens throughout the state. Recently Handel received a phone call from a landowner in northwest Illinois near Route 20 who discovered a large timber rattlesnake sunbathing on his patio. The landowner knew the snake is an Illinois threatened species and that the Survey is interested in occurrences of rare species around Route 20. So he phoned Bill who, fortuitously, was preparing for a trip to that area of the state the very next day.

When Handel arrived he was escorted to a Coleman food cooler (the kind you take on picnics) into which the landowner and his son somehow had been able to coax the rattler. Remembering to look before he leapt, Handel gingerly lifted the lid of the cooler only to be confronted by the stare of a none-too-happy, four-and-a-half-foot poisonous reptile that was not shy about displaying its displeasure with a loud agitated buzz of its tail.

Handel decided to relocate the snake a mile or so into the woods away from the house and its human inhabitants. For added security he applied a generous amount of duct tape in place of the broken latch on the cooler lid. Handel found a prairie opening in the forest that he reasoned would be suitable habitat for the snake be-

Continued on page 7

Species Spotlight

Monarch Butterfly

Susan Post and
Michael Jeffords

Long before the monarch butterfly became the state insect of Illinois it had already piqued human curiosity. C.V. Riley, Missouri's first state entomologist, noted as early as 1878 that midwestern populations of monarchs underwent birdlike migrations each autumn. Where they went, however, remained a mystery for many years. Finally, using a butterfly tagging system that involved thousands of collaborators, researchers discovered in January 1975 that monarchs from eastern North America overwinter south of the Tropic of Cancer in the mountains of central Mexico on Oyamel fir trees (also called sacred fir). Their numbers were so dense the branches literally sagged with the weight. Fir trunks were so densely clad with bright orange monarchs that they mimicked the shinglelike scaling found on each individual's wings. How these multimillion monarchs come to this place each year is perhaps the best-known feature of this remarkable creature, but it is only one aspect of the fascinating tale of the life of the monarch!

Photo by Michael Jeffords, INHS Center for Economic Entomology

The monarch butterfly, *Danaus plexippus*.

This story begins with an egg. A female monarch is an excellent, if somewhat narrowly focused, botanist and chooses only milkweeds on which to trust her young. These common plants of roadsides, fields, and prairies throughout North America are not so common chemically, and most are laced with toxic compounds called cardenolides or heart poisons. If eaten, these chemicals can cause irregular heartbeats, but have a somewhat more obvious effect on unsuspecting ingesters—they cause vomiting. Monarch caterpillars don't seem to mind the poisons and incorporate them into their bodies as a potent defense against predators. Even adults that emerge after five caterpillar molts and pupation retain the toxins. Both monarch caterpillars and adults advertise their distastefulness to the world. The caterpillars are colorfully banded with alternating white, yellow, and black stripes, while the bright orange and black adult coloration is worthy of any highway traffic warning sign! Entomologists have a name for this—aposematic coloration.

The story of migration begins with the last generation of monarchs produced in the Midwest. During most Illinois summers three generations or broods of monarchs are produced, but the last one is unique because it does not reproduce (called reproductive diapause). When the cool days of September and October approach, monarchs begin to congregate together and head in a southwesterly direction. Monarchs usually stop their flights as dusk approaches and form temporary clusters on trees or shrubs. These groups may break up the next morning or last for a few days, depending on the weather. The journey can take 75 days and individuals may average at least 50 km per day to reach the high altitude forests of the Sierra Madre, where they will spend the winter.

Midwestern monarchs are adapted to the Mexican montane forests. The cold allows them to lower their metabolic rates and activity from mid-November to mid-March while they rest quietly in the familiar dense clusters on the firs. They must conserve their fat reserves if they are to make the return flight. As the winter proceeds, mating frequency increases in preparation for the return home. After the spring equinox, monarchs return to Gulf Coast states and lay eggs on southern milkweeds to produce the first generation of new adults. These migrate northward, laying eggs as they go, as far as southern Canada. Up to three generations are produced in the upper Midwest with two produced in the south. The final, nonreproducing generation, often the great-great-great-grandchildren of the spring migrants, must then make the long return flight as the fascinating life cyle continues.

Michael Jeffords and Susan Post,
Center for Economic Entomology

The Naturalist's Apprentice

Insect Survival Strategies

Carolyn Nixon

Teacher's Guide to "The Naturalist's Apprentice"

Insects are the most diverse group of animals in the world. There are more types of insects than all other animal species combined. They are also very important in the food web, being a source of high-quality protein and fat. ***Insect Survival Strategies*** highlights just a few of the methods that insects use to survive: cryptic coloration and shape (walking stick, leaf hopper); mimicry, which is resembling something distasteful, poisonous, or dangerous (giant swallowtail caterpillar, hover fly); or warning coloration (paper wasp, monarch butterfly caterpillar). Discuss these strategies with the students and ask them to name other insects that demonstrate these same strategies. Have students describe other strategies that insects use to guarantee survival of their species.

Answers to Naturalist's Apprentice

1)h, 2)j, 3)c, 4)e, 5)f, 6)i, 7)d, 8)b, 9)g, 10)a, 11)k, 12)l

Insects are an important food for many kinds of animals, including birds, mammals, reptiles, amphibians, and even other insects. As prey, insects display many strategies to avoid being eaten by predators. Although these strategies do not totally protect them from predation, they do increase their chances of surviving and reproducing. Just a few of the many strategies are listed below. Try to match the drawings on the right with the insect and its strategy described on the left.

Insect Survival Strategies

1. The monarch butterfly caterpillar feeds on milkweed, which is poisonous to most animals. By ingesting the plant toxins the caterpillar becomes poisonous and distasteful as well. The boldly banded markings warn birds that this is not a good thing to eat.

2. Walking sticks resemble the twig of a tree on which they live and are very difficult to detect.

3. Giant swallowtail butterfly caterpillars resemble bird droppings, which are usually ignored by predators.

4. Paper wasps will vigorously defend their larvae and pupae from predators.

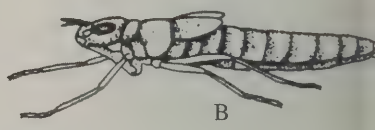
5. The upper part of the IO moth is cryptically colored to help it blend with the bark of a tree, where it often rests. If it is disturbed by a predator, it can quickly expose its hind wings, which resemble eyes of a much larger animal. This display will startle birds or other small predators, giving the moth a chance to escape.

6. Tree hoppers often resemble thorns and appear to be a part of the plant on which they are feeding.

7. The saddleback caterpillar has poisonous hairs and spines that can be very painful to any predator that tries to eat it.

8. The nymph (juvenile stage) of the dragonfly lives in water. It can take in water through short appendages on the posterior end of the abdomen, and shoot it out its anus, propelling itself with "jet propulsion."


A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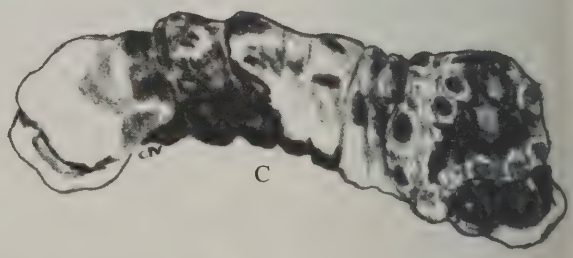
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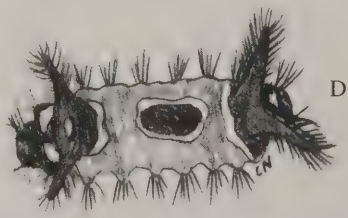
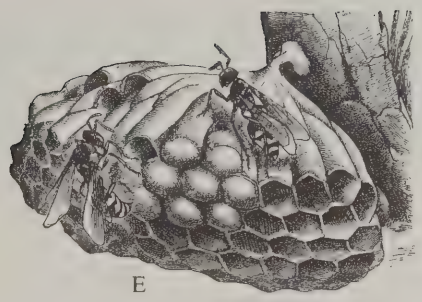

D

9. The swallowtail butterfly has tails on the hind edge of its back wings that resemble antennae. Birds often mistake the hind wings as the front of the butterfly, and when they try to grab it by the head, they bite off only a piece of the dry hind wing. The butterfly can still fly, and escapes.

10. The aquatic caddisfly larva constructs a case out of sticks and grains of sand. The case helps it blend into its habitat and protects its soft body from predators.

11. The hover fly resembles a bee in both coloration and behavior; it buzzes and hovers around flowers, and is often avoided by predators, even though it is unable to sting.

12. Blister beetles have an extremely bad taste that predators avoid.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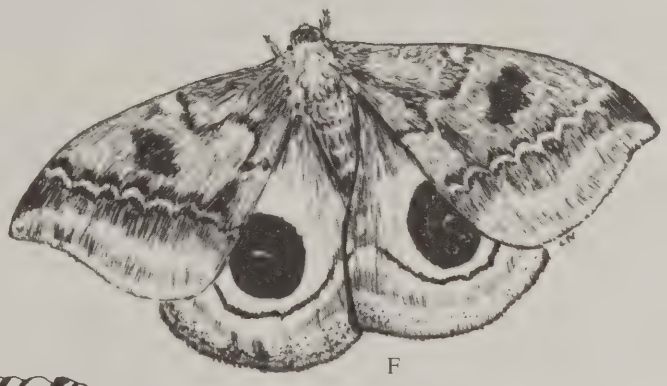
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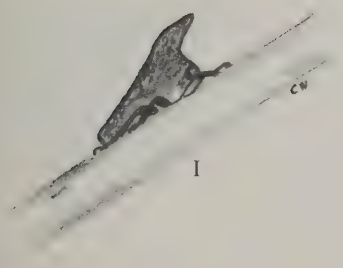
I


J


L

Looking Before We Leap. . . .

Continued from page 4

cause it had a number of fallen logs that would attract rodents (lunch for the snake). Carefully he removed the duct tape from the cooler lid, stepped back the length of his hiking stick, and used the stick to flip open the cooler lid from a safe distance. The rattler had no problem figuring out what to do as illustrated by the photo accompanying this article.

Handel explained that the rattlesnake episode culminated in a win-win-win situation—for the landowner who got rid of an unwanted intruder, for the snake that was saved by the alert timely action of the landowner, and for INHS, which was able to document the location of another threatened species and help ensure its continued survival by making sure government policymakers know the locations of rare species to help agencies avoid harming the state's biological resources. This kind of collaboration among concerned citizens, INHS, and state agencies proves to be an effective force for the preservation of nature in Illinois.

Charlie Warwick, INHS Publications Office

ILLINOIS
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607 East Peabody Drive,
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61820 USA

Turkeys

continued from front page

storm-related deaths. Most hen deaths occurred during the nesting season, when hens tend nests on the ground.

During the early part of the 1999 nesting season, nest success was higher in Clark County than in Cass County. However, two hens that hatched eggs in their nests in Clark County were killed within a week of hatching. Nest losses fall into the following categories: predation of the hen and nest, predation of nest, abandonment of the nest for unknown reasons, and flooding of nest during a heavy storm.

Turkeys are very mobile and we have observed them travelling long distances, particularly between seasons. We have observed long-distance movements of up to eight miles while hens were looking for a suitable place to nest. Turkeys also move relatively long distances in the early fall, and often return to the same wintering areas each year. Typical of much of Illinois, forest is mainly restricted to riverine areas in our study counties, and most long-distance movements have occurred along these river corridors.

Photo by Patrick Hubert, INHS Center for Wildlife Ecology

A flock of Wild Turkeys foraging for grain in a cornfield.

We will continue to look at these factors and others related to turkey ecology that may explain why some areas of the state seem to have healthier turkey populations than others. This research is already providing vital information for IDNR managers to consider when making management decisions.

Patrick Hubert and Tim Van Deelen, Center for Wildlife Ecology

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ILLINOIS NATURAL HISTORY SURVEY

Reports

ILLINOIS NATURAL RESOURCES

November/
December 1999
No. 360

INSIDE

Restoration Ecology and Research at the Illinois Natural History Survey

Restoration ecology has become a vital component of efforts to conserve biodiversity in Illinois. By applying techniques and management practices, such as prescribed fire and the planting or seeding of desirable flora, degraded ecological systems can be restored to some semblance of their original state and function. The use and development of these techniques is based on ecological principles, and the environmental benefits can be impressive. Rather than focusing on a single species, a group of species, or even a community, the goal of restoration ecology is to manage ecosystems or major habitats to at least a semi-natural condition. In Illinois, these systems include prairies, oak savannas, floodplains, wetlands, lakes, and even whole watersheds. Given sufficient scale, restoration is even relevant to the structure of entire landscapes. The benchmark of a successful restoration project is an ecological system that is self-sustaining or one that requires only periodic application of management techniques such as prescribed fire or flooding.

Photo courtesy of Midewin National Tallgrass Prairie

A prescribed burn at Goose Lake Prairie.

In this issue, we provide an overview of the research in restoration ecology that is being conducted at the Illinois Natural History Survey. A few key projects are highlighted that demonstrate the diversity of these research efforts. Scientists at the Survey are working on restoration with respect to plants, insects, soil invertebrates, and birds in nearly all of Illinois' major ecosystems. Research is being conducted throughout the state and includes projects in urban, suburban, and rural settings. This research is relevant to many conservation issues faced by the citizens of Illinois. For example, the problem of invasive or exotic species in our natural areas may be diminished with the application of restoration techniques.

Understanding how to reconstruct and sustain ecosystems poses interesting challenges for researchers. Restoration ecology is a relatively new science and fundamental questions persist about the nature of ecosystems and complex biological interactions. The practice of restoration has been called the acid test that indicates how well ecologists understand the functioning of ecosystems. Practices such as prescribed fire have been in use for most of the 20th century, but the possible effects of fire and other restoration techniques on a wide spectrum of organisms and ecological phenomena are unclear. These uncertainties, coupled with the severe loss and degradation of many important ecosystems in Illinois, highlight a complex suite of research needs. Illinois is called the prairie state but we have lost over 99% of the prairies and nearly all of the oak savannas and wetlands that were here before European settlement. Thus, research in restoration ecology and ecosystem management provides the

Continued on back page

Midewin National Tallgrass Prairie: History and Current Research

The Midewin National Tallgrass Prairie (19,000 acres) is the largest ongoing tallgrass prairie restoration in the United States. This is also the first time that a state agency (Illinois Department of Natural Resources, IDNR) and a federal agency (U.S. Forest Service, USFS) have joined forces to work on such a project. Midewin is located in Will County, just north of the town of Wilmington, approximately 40 miles southwest of Chicago.

Midewin was formerly the Joliet Army Arsenal, where the explosive TNT was produced during World War II and the Korean and Vietnam wars. In 1976 the arsenal was shut down and in 1993

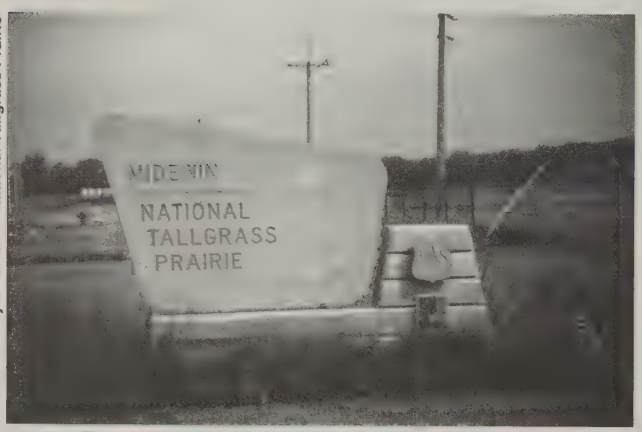

Photo courtesy of Midewin National Tallgrass Prairie

Entrance to Midewin National Tallgrass Prairie near Wilmington, Illinois.

23,500 acres of surrounding land were declared "excess federal land." Under the leadership of Congressman George Sangmeister and the Joliet Arsenal Citizen's Planning Commission, a rescue plan was developed for the land. As a consequence of this plan, the Prairie Parklands Macrosite was developed, including most of the original arsenal property together with other nearby public and private land in a natural state.

Midewin was established through the Illinois Land Conservation Act (ILCA) of 1995, legislation designating the transfer of 19,000 acres from the Army to the USFS. In 1997 almost 15,000 acres were transferred. The ILCA mandates that Midewin will be managed to meet four primary objectives: 1) to conserve, restore, and enhance the native population of fish, wildlife, and plants; 2) to provide opportunities for scientific, environmental, and land-use education and research; 3) to allow the continuation of existing agricultural uses of land within Midewin for the next 20 years, or for compatible resource management uses thereafter; and 4) to provide recreational opportunities that are not incompatible with the above purposes.

Based on 19th century records, Midewin appeared at the time of settlement to be approximately 86% prairie, 14% forest, and less than 1% swamp (wetland). Today, most of the site is pasture and cropland, with minimal native vegetation. Nonetheless, at Midewin you can find remnant native vegetation in habitats that include wetlands, woodlands, and several grassland types, ranging from tall, medium (hay), and short grass prairie. These areas contain small pockets of native diversity including blazing star (*Liatrus pycnostachya, L. spicata*), sneezeweed (*Helenium autumnale*), gentian (*Gentiana andrewsii*), sunflowers (*Helianthus* spp.), prairie plantain (*Cacalia plantaginea*), meadow rues (*Thalictrum* spp.), ironweed (*Vernonia fasciculata*), goldenrods (*Solidago* spp.), big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), prairie cord grass (*Spartina pectinata*), and switch grass (*Panicum virgatum*). Midewin has one of the largest dolomite prairies within the state. Here are found many of our endangered and threatened plant species, including the only federally endangered plant species, the leafy prairie clover (*Dalea foliosa*). Midewin has four streams: Jackson Creek, Grant Creek, Prairie Creek, and Jordan Creek. Finally, Midewin is home to 16 state endangered and threatened species, including the Loggerhead Shrike (*Lanius ludovicianus*) and the Upland Sandpiper (*Bartramia longicauda*).

The long-term plan for Midewin is to restore and reconstruct prairies and other habitats, such as wetlands. To accomplish this, the USFS has developed a native plant nursery to generate the massive seed sources that will be used for the restorations. In addition to the USFS and IDNR, restoration involves private organizations, such as the Open Lands Project, and hundreds of volunteers.

Research is being conducted by Survey staff and investigators from cooperating institutions. Chris Whelan of INHS is studying habitat selection and reproductive ecology of bird species, including Bell's Vireo (*Vireo bellii*), and Brenda Molano-Flores (INHS) is determining the breeding systems of several plant species, such as pale-spike lobelia (*Lobelia spicata*) and rattlesnake master (*Eryngium yuccifolium*). Chris and Brenda have also developed monitoring programs for the birds and plants occupying the site. Projects conducted by cooperators include studies of jumping spiders; trophic interaction chains involving fish-eating birds, fish, and their invertebrate and algal resources; and the potential for wetland restoration. Proposals for studies of insect dispersal and soil seed banks have been submitted.

The sheer scale of the restoration of Midewin is quite a challenge. Nonetheless, the effort will produce unique and valuable information on the structure and function of the tallgrass prairie ecosystem, and it will serve as an example for cooperation of federal, state, and private organizations, and volunteers.

Brenda Molano-Flores and Christopher J. Whelan, Center for Biodiversity

Prairie Restoration Research at the Savanna Army Depot

In 1908, renowned botanist Henry Allan Gleason studied the vegetation of the inland sand deposits of Illinois. Gleason published the results of this work in the October 1910 *Bulletin of the Illinois State Laboratory of Natural History* (now the Illinois Natural History Survey). The article contains detailed descriptions and photographs of the plant communities characteristic of Illinois' prairies and oak forests on sandy soil. He spent a major portion of the summer of 1908 in the Hanover area in western Jo Daviess County, which at the time still had "extensive areas of [forest and prairie] ... in their original condition, or but slightly modified by grazing."

Ten years after Gleason's study, the U.S. Army purchased 6,500 acres of floodplain forest and 6,500 acres of the upland sand area that Gleason studied near Hanover. The Army's use of this land, known as the Savanna Army Depot, spared it from the plow and most development. However, although about 5,000 acres of uplands are still dominated by native vegetation, the landscape has changed considerably since Gleason studied it. A grid of roads and railroads crisscrosses the upland area, giving access to 132 warehouses and 437 earth-covered, concrete bunkers used to store ordnance. Nearly 80 years of fire suppression and heavy grazing have led to woody encroachment in the prairies, development of a thick understory in the savannas, and establishment of invasive plants such as spotted knapweed and garlic mustard. Despite this disturbed state, the depot is the largest contiguous remnant of sand prairie/savanna in Illinois, and it harbors more than 30 state threatened and endangered species.

Next spring, the depot will close and the U.S. Fish and Wildlife Service (USFWS) will begin managing 9,500 of its 13,000 acres as the Lost Mound Wildlife Area. The upland portion of the USFWS land, approximately 3,000 acres, will be jointly managed by USFWS and the Illinois Department of Natural Resources. Two INHS scientists at the site are planning and will carry out research and restoration of the native ecosystems that Gleason studied.

Three main research projects are planned for the near future at Lost Mound. The main research will focus on approximately 500 acres of the prairie and will take advantage of the Army's grid of roads to conduct a statistically sound experiment investigating various components of prairie restoration and management, including the timing of prescribed fire, seed addition, and ground-disturbing activities. The reaction of prairie vegetation and the invasive species to these manipulations will be monitored in order to understand what controls the diversity of prairie plant communities. In addition, the effects of the management techniques on the ecology of selected grassland and shrubland birds will be studied. Of particular interest are the Grasshopper Sparrow (*Ammodramus savannarum*) and the Eastern and Western Meadowlarks (*Sturnella magna* and *neglecta*).

Another research topic will focus on species interactions with invasive species. The roles of birds and mammals as seed dispersers, seed predators, and herbivores of invasive plant species will be examined to complement the work on techniques to control invasive species. The third research topic will focus on blowouts—areas of bare sand created by wind erosion. Understanding how often these patches are created and how quickly plants fill them in will provide information on how to maintain habitat for species, such as the state-endangered false heather (*Hudsonia tomentosa*), that depend on open sand for survival.

Photo courtesy of Savanna Army Depot

Aerial view of Savanna Army Depot.

Although restoration is still in its infancy at the Lost Mound Prairie, the potential for its impact is twofold. First, restoration at the site will return a small portion of Illinois' once vast prairie to its past grandeur, providing a refuge for plants and animals in dire need of protected habitat and a place for people to experience the prairie on a larger scale than just about anywhere else in Illinois. Second, and just as important, research at the site will provide information that will help answer questions about how to restore and maintain prairies and savannas in Illinois and throughout the Midwest.

Amy Symstad and Dan Wenny, Center for Biodiversity

Restoration of Bottomland Forests in the Cache River Watershed

Floodplain forests and their associated wetlands are among the most productive, biologically diverse habitats in the world, but they are also some of the most threatened. During the past 150 years, the combined effects of logging, draining, and farming have altered and fragmented many bottomland forest ecosystems in North America. Scientists think that the fragmentation of bottomland forest habitat has contributed to declines in populations of songbirds because of habitat loss and potential increases in nest predation and brood parasitism. In recent years, researchers have recognized the importance of restoring and preserving bottomland forests, and efforts are now being made to acquire, restore, and maintain bottomland forest habitats.

Photo by Jeff Hoover, INHS Center for Wildlife Ecology

Heron Pond, the northernmost cypress swamp in the United States, is in the Cache River watershed.

The Cache River Wetlands Restoration Project, located in the southern tip of Illinois, is one of the largest habitat restoration projects in North America. The ultimate goal of the restoration project is to acquire, restore, and manage over 60,000 acres of land as bottomland forest within the Cache River watershed. The project is a joint venture involving the U.S. Fish and Wildlife Service, The Nature Conservancy, the Illinois Department of Natural Resources, and Ducks Unlimited. Presently over 32,000 acres of land have been acquired, much of which has been taken out of agriculture and planted with a mixture of bottomland tree species.

In 1993, we began studying the bird communities in the remnant bottomland forests of the Cache River watershed to determine the abundance and nesting success of the birds prior to restoration. Based on data from more than 400 census points and 3,000 nests, we found that species diversity and abundance of migratory songbirds increased and rates of nest predation decreased with increasing size (width) of tracts of bottomland forest. Brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) was prevalent everywhere, but was lowest in the largest, most unfragmented areas. These results suggest the importance of expanding medium and larger tracts and consolidating existing smaller tracts of bottomland forest.

The Prothonotary Warbler (*Protonotaria citrea*) has been the focal species for studying how natural processes, such as hydrologic fluctuations, affect the function and value of habitat for songbirds. We now know that fluctuations of water levels (both rate and amount) influence nest predation, in turn affecting season-long productivity of birds breeding in bottomland forests. We are now studying how productivity is linked to the site fidelity of adult songbirds, to the dynamics of local populations, and to a particular habitat being a "source" or a "sink" for songbirds. With continued research we will determine whether or not adult birds adaptively return to source habitats and avoid sink habitats.

Research of tree species preferences by foraging insectivorous birds during the breeding season has led to the recommendation that heavy-seeded species (e.g., hickories that are slow to recolonize restored bottomland forests) and uncommon trees that are preferred by foraging birds (e.g., silver maple) be emphasized in reforestation plantings.

Research during the winter of 1999 in the Cache River watershed established the importance of bottomland forests for wintering birds. The diversity and abundance of birds during the winter are much greater in bottomland forests than in adjacent upland forests. Also, the bottomland forest may provide critical winter habitat for birds of conservation priority (e.g., Red-headed Woodpecker, *Melanerpes erythrocephalus*; Brown Creeper, *Certhia familiaris*; and Rusty Blackbird, *Euphagus carolinus*).

This research in the Cache River watershed will ultimately fill in gaps in our knowledge of bottomland forest ecosystems, and increase our ability to effectively and efficiently restore and manage bottomland forests. We will also be able to monitor the success of the restoration over time, and use our results to assist with other bottomland forest restoration efforts throughout the United States.

Jeffrey P. Hoover and Scott K. Robinson, Center for Wildlife Ecology

Fen Wetland Restoration in Northeastern Illinois

Of all the wetland types, fens are probably the least familiar to the public. This wetland community contains peat deposits (partly decayed plant material) and calcareous (calcium carbonate containing) water seepage. Fens are usually sloped, often occurring on hillsides where seepage and springs run from the ground. Found exclusively in the northern third of the state, fens may be covered by trees and shrubs or may be dominated by herbaceous wetland communities such as sedge meadows and marshes. In Illinois, and across the United States, fens are among the rarest of wetland communities, thereby emphasizing the value of their potential restoration. Wetland restoration, in general, is of particular importance in Illinois, where over 90% of our original wetland acreage has already been lost. In northeastern Illinois, specifically, urban sprawl and development pressures of the Chicago metropolitan area are especially great.

Hickory Grove Fen, a partially drained fen located in McHenry County in northeastern Illinois, has been studied by researchers from the Illinois Natural History Survey and the Illinois State Geological Survey for several years. For many years, much of this fen had been drained by underground field tiles and aboveground ditches. Drained areas of the fen were covered with nonwetland vegetation, including thick growths of trees and shrubs, where herbaceous fen, marsh, and wet prairie plant species formerly dominated. At the suggestion of McHenry County Conservation District personnel and with funding from the Illinois Department of Transportation, a study was initiated to determine if drainage effects could be reversed, with the goal of restoring wetland hydrology and habitat.

Restoration efforts were conducted in 1996 and 1997 with the removal of drainage tiles, filling of ditches, and removal of most woody vegetation. Water levels within some areas of the fen responded almost immediately, rising significantly. In fact, water level increases in portions of the restored fen were sufficient to satisfy the wetland hydrology criterion for jurisdictional wetlands. Water levels and groundwater discharge may yet increase in the near future. Compaction of the peat soils, resulting from years of drainage, may have slowed the restoration of wetland hydrology in some areas.

Plant community restoration and development is also expected to continue with time. Covered with thickets of buckthorn (*Rhamnus* spp.) and honeysuckle (*Lonicera* spp.) prior to restoration, plant communities have since made significant improvement. Although hydrologic restoration and plant community development are still in progress, vegetation characteristic of a calcareous fen appears to be returning. In many areas where wetland hydrology has been restored, dominant hydrophytic vegetation typical of fen, marsh, wet prairie, and sedge meadow habitats now prevails. Wetland asters (*Aster simplex* and *A. puniceus*), bulrushes (*Scirpus* spp.), sedges (*Carex* spp.), Joe-Pye weed (*Eupatorium maculatum*), bugle weed (*Lycopus* spp.), and jewelweed (*Impatiens* spp.) commonly dominate these wet areas. Rare, high-quality wetland species typical of fen habitat, such as grass of Parnassus (*Parnassia glauca*), small fringed gentian (*Gentianopsis procera*), and Kalm's lobelia (*Lobelia kalmii*), also occur regularly. Vegetation and hydrologic monitoring will continue to document in the foreseeable future further possible hydrologic recovery. A corresponding development of existing plant communities should also occur, hopefully climaxing in a fully functional, high-quality fen community, a very rare Illinois habitat indeed.

Small fringed gentian (*Gentianopsis procera*).

Photo courtesy of INHS Center for Wildlife Ecology Wetlands Group

Hickory Grove Fen in McHenry County.

Photo by Brian Wilm, INHS Center for Wildlife Ecology

Brian Wilm, Center for Wildlife Ecology

How Prescribed Fire and Management Affect Plants and Animals in Central Illinois' Oak-Hickory Forests

Much of what was open woodland and savanna in Illinois has closed in and could now be considered forest. Previous to European settlement, Native Americans used fire as a management tool to maintain an open landscape, especially in the relatively high and dry oak-hickory forests and savannas. Until 1930 or so, many landowners regularly burned their woodlands. However, soon after this time with the advent of Smokey the Bear ("Only you can prevent forest fires") very little burning was done for management. In more recent times, natural areas managers have revived the use of prescribed burning in upland woodlands. Lack of fire in these woodlands may be diminishing the diversity of plant life by promoting conditions that favor a few fire-sensitive, shade-tolerant, mesophytic native plant species such as sugar maple (*Acer saccharum*), slippery elm (*Ulmus rubra*), and paw paw (*Asimina triloba*), as well as numerous exotic plant species such as buckthorn (*Rhamnus* spp.) and bush honeysuckle (*Lonicera* spp.). This trend, leading to a lower diversity of plant species, could result in lower diversity of insects and other organisms that are dependent on particular plant species.

Photo by R.L. Larimore, INHS Center for Wildlife Ecology

A white oak (about 250 years old) in Baber Woods showing the dieback of lower branches caused by crowding from sugar maples.

In two oak-hickory forests, researchers at the Illinois Natural History Survey are comparing the effects of withholding fire to prescribed burning (in combination with other active management such as selective use of herbicides) on the abundance and diversity of vascular plants, insects, gastropods, soil invertebrates, birds, and lichen communities within these sites. The study areas are Baber Woods Nature Preserve in Edgar County and the Middle Fork Fish and Wildlife Area in Vermilion County. Our extensive studies at Baber Woods show a trend of declining oak reproduction since 1965 with virtually no production in 1998. Management at Baber Woods was initiated in fall 1999. Effects of fire and other management practices will be evaluated by conducting similar studies on nearby control plots. Comprehensive studies were initiated in both restoration sites and the control plots in spring 1998.

Insects

For insects, 100 sweeps are taken with a sweep net along permanent 50-m transects in the experimental and in the nearby control areas. Malaise traps are run for week-long intervals several times per year for each site. Blacklight traps are run at night once or twice a year. Changes in species richness and composition will be monitored by counting morphospecies in these samples.

Birds

Local abundances and community structure of birds are being estimated during the breeding season using the "point-count" method of censusing. Data from the 1999 breeding season indicate that the diversity of birds in Baber Woods is relatively high for central Illinois. Some species will likely benefit and some will be adversely affected by restoration.

Plants

All vascular plants, both

Continued on page 8

Community-Level Parameters as Indicators of Restoration Success in Fire-Effects Studies

Restoration of vegetation typically attempts to redress ecological consequences of habitat loss and degradation and can occur at the species, community, landscape, or ecosystem scales. Restoration at the landscape or ecosystem levels can involve attempts at planting entire vegetation communities and can be defined more accurately as "reconstruction." Examples of species-level restoration include population enhancements, species (re)introductions, and control efforts targeting particular pest species such as a non-native, invasive species. Community-level efforts in the Midwest often involve the reintroduction of natural ecological processes such as a fire regime.

Studies of fire effects on vegetation are particularly informative to restoration ecologists because fire management increasingly is used to restore plant community types that appear to be dependent on periodic fire. Examining the effects of fire in terms of species-response types, survival mechanisms, physiognomic group response, and analysis of biodiversity trends leads to better understanding of how fire affects community structure and organization. These results, particularly from longer-term studies that exceed transient (short-term) responses, can lead to better predictions about the potential of restoration activities that rely on fire alone.

Results from a seven-year study of fire effects in a dry barrens remnant in southern Illinois (described briefly in the May/June issue) indicated that significantly more ground-cover species increased in frequency and percent cover in the fire-treatment vegetation than in the nearby fire-free control vegetation. Most of the increased occurrences among species appear to be from repositories in soil seed banks and all were native species appropriate for the habitat. The taxa that increased in frequency of occurrence and the numerous newly emerged species in the sample data following the fires indicate that the soil seed bank of barrens remnants can provide an important refugium for species to survive not only fire but changing ecological conditions. Such changes in ecological conditions are typically caused by increased shade from encroachment of woody overstory vegetation. While most species in the ground cover increased in occurrence frequency and many also increased in percent cover, only eight species declined in both cover and frequency and six of these were woody plants. Typical management goals of fire use in savannalike habitats include reducing the abundance of woody species because the shading effects on ground-cover species usually result in lowered percent cover and lower floristic diversity. Abundance of woody vines also declined with fire; however, most other physiognomic groups increased with fire including annuals, perennial forbs, grasses, and sedges. These changes were not always concurrent among these groups. Annual species increased dramatically following each fire, rapidly returning to near baseline levels in the second year, while perennial grasses initially declined in overall abundance and then increased greatly until the next fire. In contrast to the results from fire-treatment vegetation, about 58% of the species in unburned barrens vegetation decreased in frequency (32% of the ground-cover species decreased in both cover and frequency) including a much greater proportion of taxa that became extirpated from the sample area.

A prescribed burn at Gibbons Creek Barrens.
Photo by John Taft, INHS Center for Biodiversity

At each scale measured (0.25-m^2, 0.05-ha, total site) there was an increase in diversity at the treatment site and, perhaps equally as noteworthy, a decline

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Prescribed Fire in Oak-Hickory Forests

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woody and herbaceous, have been surveyed and changes in the composition of the plant community will be compared to changes in species composition and abundance of other organisms over time.

Chris Dietrich, INHS entomologist, with Photo Tactic Optimal Insect Extractors that he invented to help separate insects from samples using light.
Photo by R.L. Larimore, INHS Center for Wildlife Ecology

Soil Fauna

Researchers are also taking soil samples to study the soil fauna. Soil fauna are complex and play important roles by decomposing dead plant material, recycling limited plant nutrients, and forming soil structure and new soil. Management practices that affect the soil community can therefore impact the plant community. We believe that soil fauna have the potential to serve as informative indicators of ecosystem health and disturbance in natural communities.

Lichens

Lichens were surveyed on the larger trees, oaks in particular. These trees were then mapped for future reference and qualitative and quantitative calculations were made. The lichen community, perhaps due to low light levels, was not extensive at either site, and due to its slow growth and difficulty in identification, will not be studied in detail until several years after a prescribed burn.

Gastropods

Terrestrial gastropods (snails and slugs) number over 100 species in Illinois and occupy many different habitats. How these animals may respond to an increase in herbaceous plants as a result of more light reaching the ground is an interesting question. From all our sites we have found and identified a combined total of 20 species of gastropods.

This study is one of the few to assess the effects of restoration on a wide range of organisms and we hope it will serve as a model for larger-scale, long-term studies of restoration in Illinois. Such studies will provide much-needed information for procedures of woodland management that optimize species abundance, diversity, and stability.

Richard L. Larimore, Chris Dietrich, Ed Zaborski, Dave Ketzner, Jeff Brawn, INHS; Bob Szafoni, University of Illinois; and John Ebinger, Eastern Illinois University

Indicators of Success in Fire-Effects Studies

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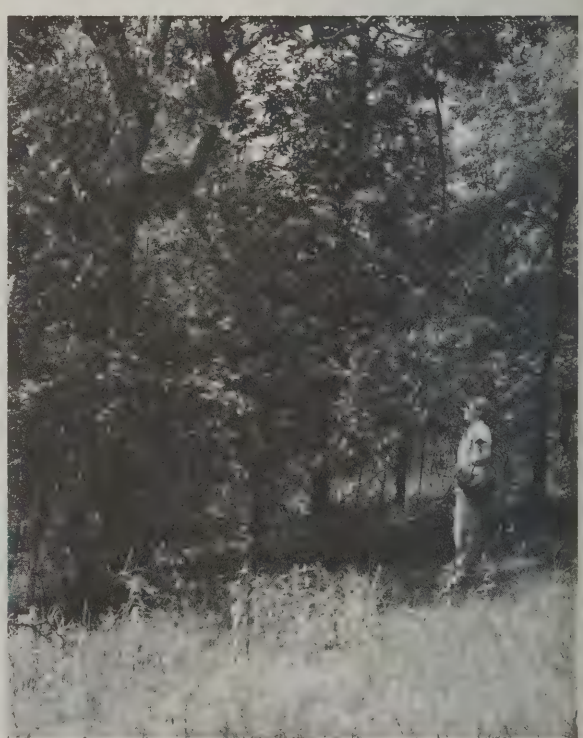
at the untreated (control) site. These results not only point to the potential for recovering diversity with restoration activities, but also indicate there can be a cost in the absence of restoration. In a highly fragmented landscape such as in Illinois, where habitat remnants are isolated from suitable sources of species enrichment, maintaining diversity among individual sites is critical to the long-term potential for sustaining current levels of biodiversity within the state. Presently, only a minority of sites receive restoration efforts. If the trends detected in only a seven-year period at the control barrens are occurring in other open woodland and savanna habitats throughout Illinois, the erosion of floristic diversity may be occurring at a pace that challenges even the most aggressive restoration program and compounds our interest in the soil seed bank.

John B. Taft, Center for Biodiversity



Plot at Gibbons Creek Barrens after recovery from a prescribed burn.
Photo by John Taft, INHS Center for Biodiversity

Species Spotlight

Little Brown Bat

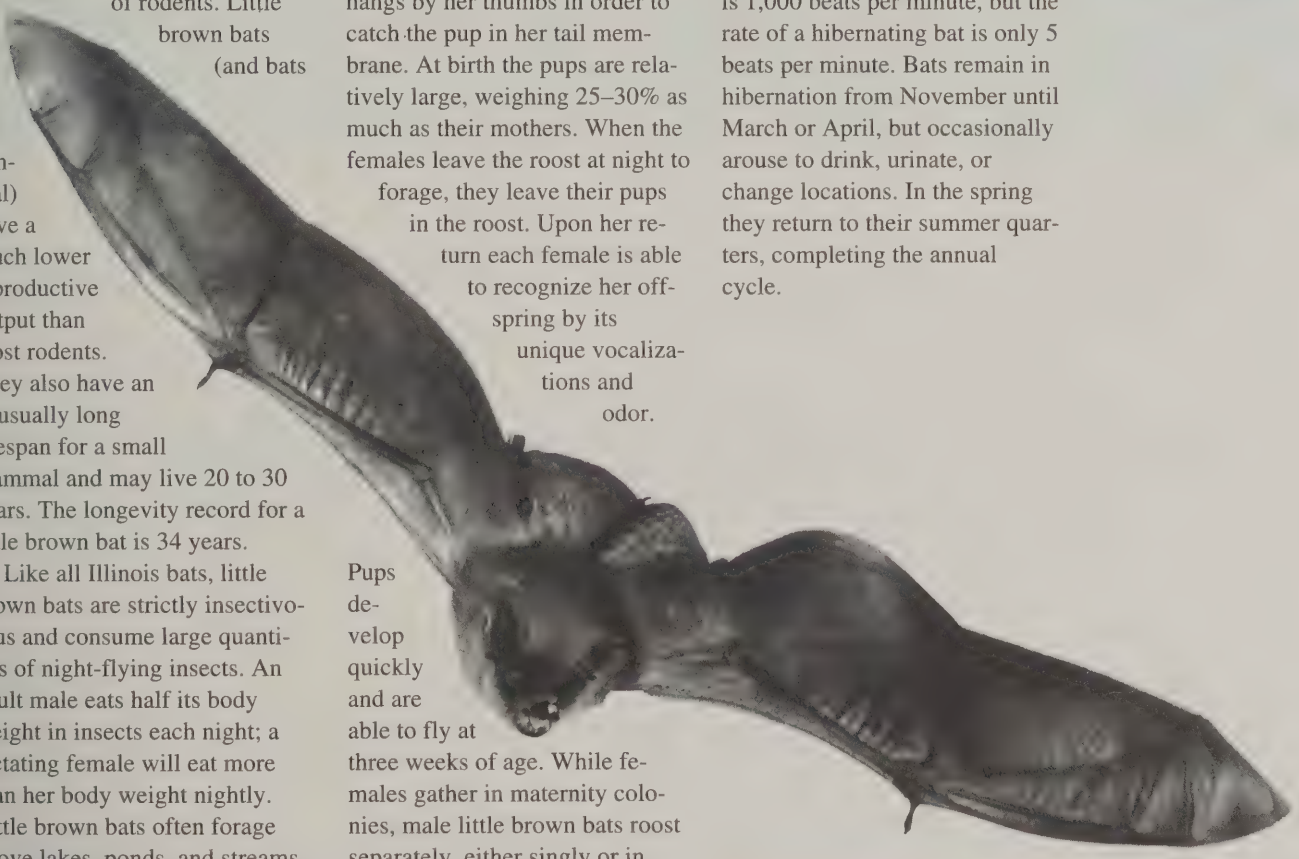
Joyce Hofmann

The little brown bat (*Myotis lucifugus*) is one of the most common of the 12 bat species that occur in Illinois. It lives throughout the state during the summer and is the most abundant bat found hibernating in Illinois caves and mines during the winter. Little brown bats have glossy brown fur and wingspans of 9 to 11 inches. They may resemble mice with wings, but their life history is very different from that of rodents. Little brown bats (and bats in general) have a much lower reproductive output than most rodents. They also have an unusually long lifespan for a small mammal and may live 20 to 30 years. The longevity record for a little brown bat is 34 years.

Like all Illinois bats, little brown bats are strictly insectivorous and consume large quantities of night-flying insects. An adult male eats half its body weight in insects each night; a lactating female will eat more than her body weight nightly. Little brown bats often forage above lakes, ponds, and streams, sometimes zipping back and forth repeatedly through swarms of aquatic insects. Their prey include midges, moths, caddisflies, mayflies, small beetles, and mosquitoes which they find by echolocation—the perception of objects using the reflection of sound waves emitted by the bats.

During the summer female little brown bats form maternity colonies. A colony typically consists of a few hundred females, but may include several thousand individuals. Maternity colonies typically roost in the attics of buildings or the rafters of barns. They may also take up residence in bat houses. Little brown bat females choose roost sites where the temperature can exceed 100°F; such high temperatures promote the pre- and postnatal development of their young. Each female gives birth to a single pup, usually during June. During birth, the female reverses her normal roosting position and hangs by her thumbs in order to catch the pup in her tail membrane. At birth the pups are relatively large, weighing 25–30% as much as their mothers. When the females leave the roost at night to forage, they leave their pups in the roost. Upon her return each female is able to recognize her offspring by its unique vocalizations and odor. Pups develop quickly and are able to fly at three weeks of age. While females gather in maternity colonies, male little brown bats roost separately, either singly or in small bachelor colonies. Males roost in a variety of cooler sites including buildings, caves, mines, bridges, and trees.

During late summer and autumn, little brown bats accumulate large amounts of body fat, which will be their winter energy supply, and migrate up to 200 miles to a suitable cave or abandoned mine for hibernation. Mating occurs before the bats enter hibernation; however, because of a rare reproductive process called "delayed fertilization," females do not ovulate and become pregnant until the following spring. Little brown bats choose hibernation sites with temperatures several degrees above freezing, minimal air flow, and very high humidity. There they hang singly or in small clusters. During hibernation a bat's body temperature drops to about 40°F, drastically slowing all of its body functions. For example, the heart rate of a little brown bat in flight is 1,000 beats per minute, but the rate of a hibernating bat is only 5 beats per minute. Bats remain in hibernation from November until March or April, but occasionally arouse to drink, urinate, or change locations. In the spring they return to their summer quarters, completing the annual cycle.



Little brown bat, *Myotis lucifugus*.

Photo from INHS Image Archives

The Naturalist's Apprentice

Build a House for Bats!

Carolyn Nixon

Teacher's Guide to "The Naturalist's Apprentice"

Build a house for bats!

Bats can eat large numbers of night-flying insects, so many people are now realizing their benefits. Bats can be enticed to roost during the day and even rear their young in bat houses. A simple bat house can be constructed from the following plans. Bats like tight-fitting places, so even though the space looks crowded to you, it will not look that way to a bat. Bats prefer warm houses, so placement of the house is important. Position the house 15 to 20 feet high on an exposure that receives at least 6 hours of sunlight. Any exposure except north should be fine. The best sites are 20 to 25 feet from trees and other obstructions. Houses should be placed on the side of a building or on a pole, not in a tree. Put the bat house in place in April or May. It may take a year or more before the house is occupied. Bat houses within a quarter of a mile of water, such as a river, stream, or pond, are more likely to be successful in attracting bat residents.

Constructing the bat house

• Cut the bat house pieces from 1 x 10 board using the dimensions shown in the diagrams. All surfaces shown with cross hatches should be roughened so the bats can grip them. If the surface is not already rough, brush it vigorously with a wire brush, or staple plastic window screening material to the smooth wood.

• Nail or screw the bat house together. Drilling small pilot holes for the nails or screws will help prevent the wood from splitting. Take special care when placing the center partition so that the spaces are 3/4 inch wide. It should also be placed about 1/2 inch from the top, fastened to the side panels only. The front ventilation hole should be about about 1/2 inch wide. All seams are caulked with latex caulk. All exterior surfaces, except for the landing stage, should be painted with at least two coats of exterior latex house paint of a dark color, preferably dark brown, gray, or green. The interior and the landing stage should be left unpainted.

• Screw or nail the bat house to the side of a building or pole.

Teachers or parents

Supplies needed: one 6-foot-long 1" x 12" board such as pine or rough-surface cedar (rough-surface cedar will have one side that is already rough enough for a bat to grip); 30 1 1/4"-long nails or screws; latex caulk; dark-colored latex paint.

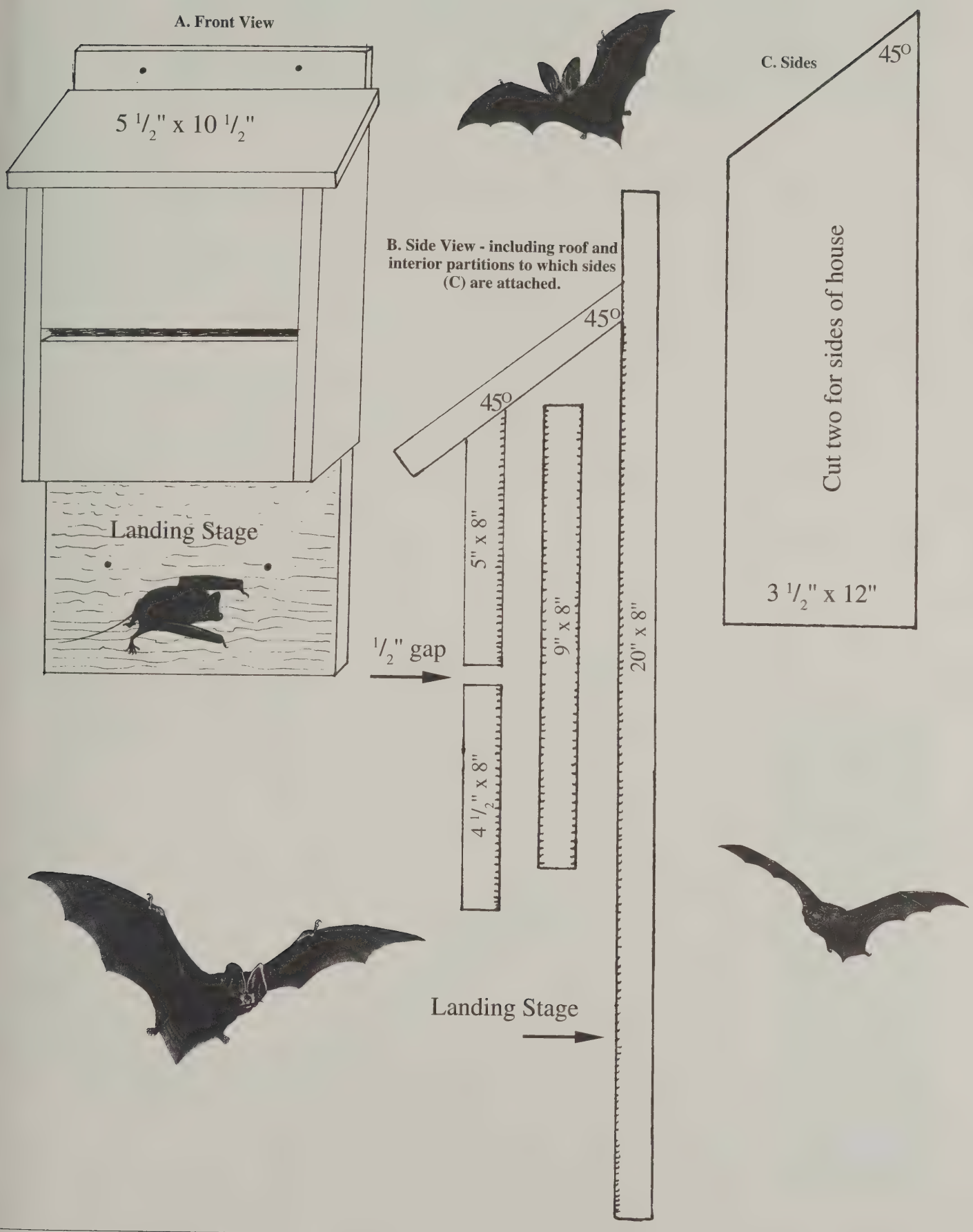
Tools needed: wire brush, hammer or screwdriver, paint brushes, drill with bit slightly smaller than the diameter of the nails or screws.

Cut the wood pieces out for younger children, or have a shop class cut them out. The upper front panel and the roof must be cut at a 45-degree angle. Plywood can be used instead of cedar or pine, but if it is of a different thickness (1" lumber is actually about 3/4" thick), you will have to adjust the size of the side panel and roof. Different species of bats prefer different spaces for roosting, but this bat house is a good compromise for most. Spaces between partitions can be as small as 1/2 inch for some species, and as large as 1 inch for others.

Please remind everyone not to touch the bats.

If you get bats in your bat house, let us know! (e-mail or write.....)

c-nixon2@uiuc.edu
Carolyn Nixon
Illinois Natural History Survey
607 E. Peabody Dr.
Champaign, IL 61820


A. Front View
5 1/2" x 10 1/2"
Landing Stage
B. Side View - including roof and interior partitions to which sides (C) are attached.
45°
45°
5" x 8"
9" x 8"
20" x 8"
1/2" gap
4 1/2" x 8"
Landing Stage
C. Sides
45°
Cut two for sides of house
3 1/2" x 12"

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Restoration Ecology

continued from front page

citizens of Illinois with the means and knowledge to regain at least part of our natural heritage. Trade-offs are inevitable and land managers or private landowners need reliable scientific information upon which to evaluate different land-use options.

Restoration ecology also presents unique research opportunities because it draws on knowledge from diverse areas in ecology and systematics over a wide spectrum of taxonomic groups. The potential for synthesis and integrative research is therefore excellent. As illustrated in this issue, projects in restoration ecology can bring together teams of scientists for research at the same location on common questions. Restoration techniques, such as the burning of grassland habitat, can involve decisions about the timing and frequency of burning with results that may have positive and adverse effects on different types of organisms. The collective efforts of researchers to understand these trade-offs are essential for effective restoration.

The application of restoration techniques at the level of ecosystems also allows scientists to work at an unusually large spatial scale. Under ideal conditions, restoration projects offer the advantages of experimental studies that are usually conducted in much smaller or simpler ecological systems. Long-term comparisons of different restoration techniques are especially informative.

Research in restoration ecology at the Illinois Natural History Survey will certainly increase in coming years and projects are being planned to monitor comprehensively the long-term effects of restoration. Likely areas for these efforts are the Illinois River Watershed, the Midewin National Tallgrass Prairie, and the Savanna Army Depot (soon to become the Lost Mound Wildlife Area). The Survey already has staff located in all these systems. Data from ongoing and planned projects will enhance our understanding of how ecosystems work and will be critical for predicting the sustainability of Illinois ecological systems in response to increasing local and global pressures.

Jeffrey D. Brawn, Center for Wildlife Ecology

ILLINOIS NATURAL HISTORY SURVEY

Reports

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INSIDE

Snakes in the Grass, Snakes in the Trees

Snakes are difficult to study in the field because of their secretive behavior, and many features of their ecology and natural history are not well known. Although snakes are frequently considered vermin and often indiscriminately killed by humans, most species of snakes are harmless to humans, and many serve in beneficial roles as predators of small mammals and invertebrates. Because many species of snakes are declining in numbers in regions where the land is dominated by row-crop agriculture, such as in central Illinois, it is important to identify and protect critical habitats and landscape features relevant to their conservation. For example, sites used for hibernation may be particularly important for snakes living in temperate climates. Conservation biologists also have recently begun to suspect that some species of snakes may be major predators of the eggs and nestlings of songbirds. Studies of habitat use by snakes could help resource managers determine if local manipulations of habitat could improve nesting success for declining species of songbirds.

We used radiotelemetry to monitor habitat use by black rat snakes (*Elaphe obsoleta*), fox snakes (*Elaphe vulpina*), and blue racers (*Coluber constrictor*) at the Middle Fork Fish and Wildlife Area (MFFWA) in Vermilion County, Illinois. In Illinois, black rat snakes may grow to about 68 inches long, fox snakes may grow to about 51 inches, and blue racers may grow to about 60 inches. All three species feed on a variety of small mammals, and may prey on nests of birds. Blue racers have the most general diet, which includes a variety of arthropods, annelids, amphibians, and reptiles.

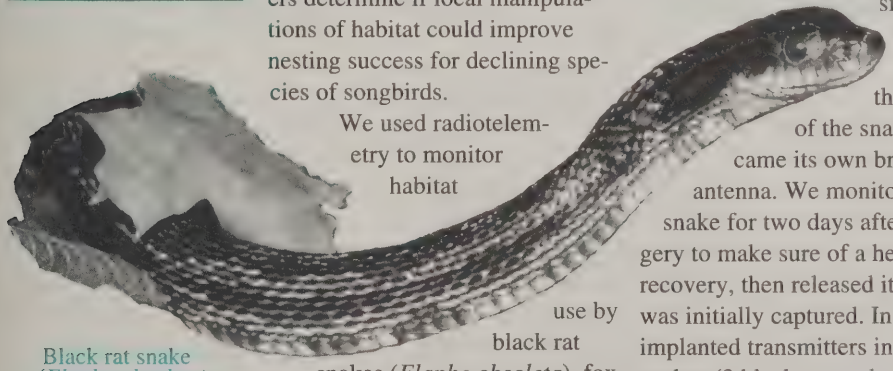
Because these three species are similar in size and diet, we wanted to see if they differed in habitat use.

You can't put a radiocollar on a snake. Instead, we brought each snake that we captured to a surgical facility at the University of Illinois where, with the help of professional veterinarians, we anesthetized it with isoflurane gas and inserted a small radio transmitter into the body cavity. A flexible, slender wire antenna was inserted under the scales but above the muscle layer along the side of the snake. Thus, the body of the snake became its own broadcast antenna. We monitored each snake for two days after surgery to make sure of a healthy recovery, then released it where it was initially captured. In all, we implanted transmitters into 7 snakes (3 black rat snakes, 3 fox snakes, 1 blue racer) in 1997 and 17 snakes (10 black rat snakes, 2 fox snakes, 5 blue racers) in 1998.

We tried to locate each snake about three times per week during the spring and early summer, then about once per week in the late summer and fall until they moved to their hibernation sites. Each time we located a snake, we recorded the habitat in which the snake occurred, and whether the snake was below ground, on the soil surface, or above ground in vegetation. We also plotted the locations of each snake on maps of the MFFWA, and used a geographic information system (GIS) to conduct spatial analyses. These analyses allowed us to compare use of a type of habitat to the amount of that habitat available to each snake, and thus statistically evaluate selection and avoidance of habitat types.

Black rat snakes at the MFFWA were most frequently located in forested habitat. In contrast, fox snakes and blue racers both were typically found in prairies and old fields, and avoided forests. All three species generally avoided agricultural fields. Another interesting pattern to emerge involved the use of vertical space. Almost 50% of all the locations of black rat snakes were high up in trees, and an additional 15% of locations were in vegetation but below about 10 feet above the ground. The remaining 35% of locations were on the soil surface or below ground, most likely in rodent burrows. In contrast, all locations of fox snakes were on the surface or below ground. Blue racers

Continued on back page



Black rat snake (*Elaphe obsoleta*).

Photo by Larry Keller, University of Illinois

Human Impacts on Groundwater Quality and Subterranean Aquatic Biota in Southwestern Illinois

Groundwater under much of Illinois receives recharge water through the slow process of percolation through thick glacial till and loess. These layers filter out suspended sediments and bacteria, and allow time for breakdown of chemicals. But around the western and southern edges of Illinois, soluble carbonate bedrock is covered with only a thin layer of soil (or none), and there is little or no filtration of surface runoff before it reaches the shallow aquifer in the bedrock. Over time, the action of slightly acidic water enlarges cracks, fissures, and bedding planes in the limestone bedrock to create a system of conduits that can rapidly transport water from funnel-shaped sinkholes at the surface, through caves and smaller conduits, to resurge at springs in nearby valleys. In the Salem Plateau of Monroe and St. Clair counties this terrain, known as karst, is extremely vulnerable to environmental perturbations affecting groundwater quality and the aquatic communities.

Don Webb of INHS collecting monthly groundwater chemistry data (Monroe Co., Illinois).

Photo by Steve Taylor, INHS Center for Biodiversity

Caves and other smaller subterranean cavities in the Salem Plateau are home to a variety of unique organisms found nowhere else in Illinois. Flatworms, snails, isopods, amphipods, pseudoscorpions, millipedes, and springtails have adapted to this environment of constant darkness and fairly constant temperature. Many of these animals have lost body pigments and functional eyes and have evolved attenuated appendages, heightened tactile and chemosensory abilities, and lowered metabolic rates relative to their surface cousins. Among these creatures is the Illinois cave amphipod *(Gammarus acherondytes)*, a federally endangered crustacean found only in the subterranean streams of Monroe and St. Clair counties. The increasing pressure from urban development associated with the growth of the St. Louis metropolitan area threatens the Illinois cave amphipod and the health of the subterranean aquatic community.

As more people build homes in the hilly karst terrain, roads are widened, wood lots are cleared, farm fields give way to new suburbs, and the demand for water increases. Because most of this development is rural, and because it is taking place at such a rapid pace, there is no centralized sewage treatment system. Instead, most homes have private septic systems that do not always adequately treat the sewage before

Continued on next page

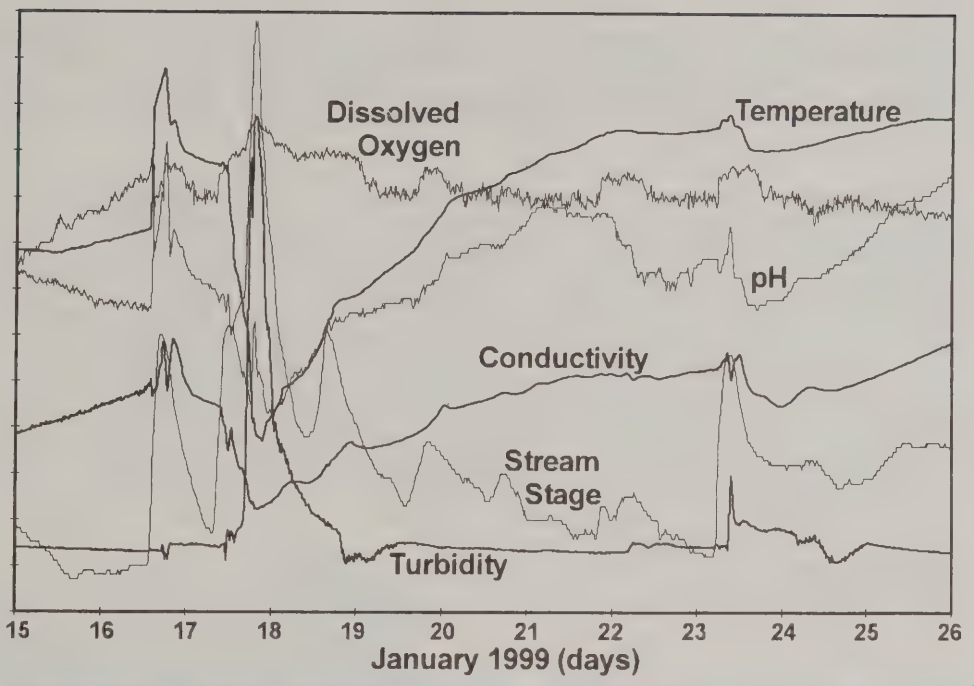
Aquatic Biota

continued from previous page

releasing it into the shallow soils or, worse, directly into sinkholes leading into the underground streams. This partially treated water ends up in the groundwater almost instantaneously and without filtration or chemical breakdown. We are concerned about the potential impacts of this septic waste, as well as runoff from lawn-care and agricultural pesticide and fertilizer applications, sedimentation associated with farming and development, and fecal material associated with livestock.

Our current research focuses on developing a more complete understanding of the shallow groundwater in four drainage basins in which the Illinois cave amphipod has been reported. Using two Hydrolab data loggers, we monitor pH, specific conductivity, dissolved oxygen, stream stage, temperature, and turbidity every 10 minutes throughout the year. These data provide a detailed picture of how the cave stream responds to rainfall events, how the water chemistry changes throughout the year, and allows comparisons to be made between caves. In addition, monthly collections of water and sediment samples are tested for bacteria, pesticides, heavy metals, and cations and anions.

We are beginning to see a variety of factors implicated as potential threats to the subterranean community: high turbidity during spring floods may reflect upon agricultural practices and development; herbicides show peak levels in water samples during the late-spring applications to row crops; and alarmingly high levels of fecal coliform and fecal streptococcus bacteria during the springtime indicate that fecal waste from livestock and/or humans is entering the groundwater rapidly and with little filtration. Use of springs and shallow wells as a source of drinking water can pose a serious health risk, especially during the rainy season, when bacteria such as *Enterococcus* (formerly *Streptococcus) faecium*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiella pneumoniae,* and *Staphylococcus aureus* are more abundant. The Hydrolab data also point towards a problem with oxygen depletion in one of the caves, probably in association with unnaturally high levels of organic inputs into the system. Because the aquatic cave community is adapted to low levels of nutrient input (there are no primary producers in these systems), increasing the organic input increases the competitive advantage of less cave-adapted, more opportunistic species, changing the community structure.



Ten days worth of data from the Hydrolab datalogger in Stemler Cave (St. Clair Co., Illinois). The data clearly record a major flood pulse event during January 17–19.

As we gradually learn more about the groundwater in the karst region, we are also learning more about the amphipods, their life histories, and microhabitat usage. Improving our understanding of the threats from human activities in the karst region will lead to the development of more objective strategies for the recovery of the amphipod and for the management and protection of the ecologically unique karst of Illinois' Salem Plateau. A major emphasis on education is crucial if we are to effectively implement changes in land-use practices associated with urbanization and agricultural activities in this area, and changes that help sustain the aquatic cave community will also improve the quality of life for Illinois residents in this karst area.

Cave amphipods foraging among stream gravels. Note how sediments can fill the spaces between the stones—spaces that are home to the amphipods.
Photo by Jeff Swayne

Steven J. Taylor and Donald W. Webb, Center for Biodiversity

Effects of Common Carp (*Cyprinus carpio*), an Exotic Fish, on Aquatic Ecosystems

Despite the popularity of common carp (*Cyprinus carpio*) in Europe and Asia, most people in North America consider these fish pests. General ill will towards carp has not prevented the spread of these large minnows into nearly every aquatic habitat in North America. Concern over the potential harm that common carp could have on native fishes and waterfowl has led to attempts to remove these carp, using water-level control, toxicants, seining, electrofishing, angling, and barriers. However, carp are able to quickly recolonize open systems, making removal schemes a costly, high-effort, ongoing process. Despite concern over the impact of carp on native fishes, little work has been done to experimentally determine the specific environmental effects of common carp.

Our research was designed to quantify the effects of carp on aquatic systems, and to test the effectiveness of a plastic mesh substrate covering in diminishing these effects. Two sets of experiments were used to determine how carp affect turbidity, water column nutrient concentration, phytoplankton, zooplankton, aquatic macrophytes, and aquatic macroinvertebrates. In 1997, we set up four treatments within drainable one-acre ponds: carp and mesh, carp without mesh, mesh without carp, and a control with neither carp nor mesh. All treatments with carp were stocked with a high biomass of adult males. Results thus far show carp to have strong effects on turbidity, total phosphorus concentration in the water column, macroinvertebrates, and aquatic macrophyte cover. No significant differences in phytoplankton or total nitrogen concentration were found between the treatments. Mesh substrate treatments significantly reduced the effects of carp on aquatic macrophyte loss. Macroinvertebrates, such as odonates, associated with macrophyte cover responded positively to the mesh treatment.

In 1998, we ran an experiment designed to determine if the effects that we saw in 1997 could be attributed to carp specifically or to a high biomass of benthic fish in general. Once again, we used four treatments in one-acre ponds: high biomass of carp, low biomass of carp, high biomass of channel catfish (*Ictalurus punctatus*), and a no-fish control. Preliminary results show that carp increase turbidity and total phosphorus concentration and decrease macrophyte cover to a greater degree than channel catfish, and lower carp biomass treatments had levels intermediate between high carp and no fish. Turbidity in the carp treatments was found to consist primarily of inorganic sediments. This experiment supports the idea that carp, an introduced fish, have a more extreme effect upon aquatic systems than native benthic fish, and that the magnitude of these effects is partly related to the ability of carp populations to achieve a high biomass.

INHS researcher Joe Parkos with common carp at Max McGraw Wildlife Foundation. **Photo courtesy of Richard Stockman**

The goals of our research were to determine the environmental effects of common carp and to evaluate plastic mesh substrate covers as a carp management strategy. Carp increased turbidity through the resuspension of bottom sediments, caused the loss of macrophyte cover due to low water clarity and uprooting, released phosphorus normally locked up within bottom sediments and aquatic macrophytes, and lowered the abundance of macroinvertebrates by predation and loss of habitat. Plastic mesh substrate covers reduced the loss of submerged vegetation and associated macroinvertebrates, but did not diminish the effects of carp on turbidity and phosphorus. Further analysis will assess potential effects on zooplankton in pond experiments. In addition, we are also making comparisons of aquatic macrophyte cover and macroinvertebrate biomass on mesh versus nonmesh plots on six field sites in northern Illinois.

Our research highlights both the effects of a benthivorous fish on an aquatic food web and the ecological traits that allow common carp to be successful invaders. Fish that are active foragers along the sediment-water interface can shift aquatic systems from a clear-water, aquatic macrophyte-dominated state to a turbid, relatively macrophyte-free condition. By reducing submerged vegetation and water clarity, common carp create conditions under which other fish, especially large predators, may suffer. Potential reduction in predator recruitment combined with high fecundity, fast growth rate, wide physiological tolerance, and omnivorous diet result in the common carp having the ability to spread into nearly any aquatic habitat. Future research will assess the effects of common carp on growth and recruitment of important sport fish, such as bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*).

Joe Parkos III and David Wahl, Center for Aquatic Ecology; Victor Santucci, Jr., Max McGraw Wildlife Foundation

Influence of Intercropping and Trap Cropping on Diamondback Moth and Its Natural Enemies

Insect pests attracted to crops grown as monocultures can sometimes be sidetracked by planting noncrop or alternate-crop plants nearby. These alternative plantings may also favor natural enemies that attack the pest insects. Trap cropping and intercropping are production practices in which this "neighborhood alteration" effect can be used as a pest management tool to reduce insecticide applications to the main crop. With trap cropping, plants particularly attractive to the target pest are grown in a small part of the field to lure the pests away from the main crop. Intercropping involves planting two or more crops simultaneously or sequentially in various row arrangements within a field. Specific plants may be chosen as intercrops because they restrict or inhibit the pest insects' ability to locate and colonize the main crop.

Intercropping and trap cropping were evaluated as ways to reduce populations of the diamondback moth (*Plutella xylostella*) on cabbage in a three-year study by University of Illinois Department of Entomology graduate student Angel Gonzalez, working with Survey entomologist Cathy Eastman. The diamondback moth, a worldwide pest of crucifers, such as cabbage, is resistant to several insecticides and is often the most numerous caterpillar attacking crucifers in Illinois. For the experiment, cabbage was grown alone, in plantings with border rows of mustard and sweet alyssum as trap crops, or in various row-intercrop arrangements with cabbage as main crop and tomato, sweet corn, soybean, safflower, or sweet alyssum as intercrops.

Populations of diamondback moth and important natural enemies were monitored to determine if the presence of trap crop or intercrop plants would decrease pest establishment and increase numbers of natural enemies. The study was conducted at the University of Illinois Vegetable Crops Farm in Champaign.

Because mustard and sweet alyssum were more attractive than cabbage for egg laying by diamondback moths in laboratory tests, they were selected as the trap crops. When planted as trap crop borders along rows of cabbage, mustard and sweet alyssum reduced diamondback moth populations on cabbage within those plots compared to those in the monoculture. But this was only effective when the trap crops were sprayed with insecticides at 14- to 18-day intervals. If not controlled, diamondback moth populations developing on the trap crops spilled over into the cabbage grown within those plots, resulting in pest numbers equal to those in the monoculture plots.

Diamondback moth larvae dining on cabbage. Photo courtesy of Jeff Wyman, University of Wisconsin

The presence of soybean and safflower as intercrops did not influence diamondback moth numbers, but sweet alyssum as an intercrop increased their numbers on cabbage within the plots. Cabbage intercropped with sweet corn had fewer caterpillars compared to the monoculture during one year but not in the second year. Tomato reduced diamondback moth populations in some intercrop arrangements but not others. It was most effective when planted in close association with cabbage.

Six species of parasites attacked diamondback moth in this study. Although parasitism by the major species (*Diadegma insulare*) was as high as 95% in some plots, parasitism by this insect was not increased significantly in intercrop or trap crop treatments. Parasitism by the second most common species (*Microplitis plutellae*), however, was increased in the sweet alyssum-safflower-sweet alyssum-cabbage treatment.

The lady beetle *Coleomegilla maculata* was the most common predator. Its numbers were considerably higher on cabbage in treatments that contained corn in the pollen-shedding stage. This predator was probably attracted to both aphids and pollen in the corn-intercrop treatments because these are important food sources.

The overall goal of this research is to improve cultural practices as components of pest management programs for diamondback moth in cruciferous vegetables. This study provided valuable clues to diamondback moth response to altered planting arrangements and possible effects on important natural enemies.

Angel Gonzalez, University of Illinois, and Cathy Eastman, Center for Economic Entomology

Species Spotlight

Tulip Trees

Susan Post

During presettlement times, the forest along the Wabash River in Illinois contained trees of prodigious size. In 1871 Robert Ridgway, a Smithsonian naturalist, measured several of these immense trees. Among the giants were tulip trees, *Liriodendron tulipifera*, which were second only to the sycamores in size. Ridgway describes one of the large tulip trees: "The finest individual found prostrate was one cut for lumber near Timberville, Wabash County, Illinois; it measured one hundred and fifty-eight feet in total length, while the trunk was twenty-three feet in circumference three feet from the base, and eighteen feet in circumference at seventy-four feet further up, where the first branch grew; the trunk perfectly sound and symmetrical throughout."

Stately tulip trees and insets of tulip tree flower and leaf.
Photos by Michael Jeffords, INHS Center for Economic Entomology

The natural range of the tulip tree lies east of the Mississippi River in the central hardwood region. The best original stands covered the rich valleys and fertile coves in association with the southern Appalachian mountain ranges and certain districts lying both east and west of them. The trees prefer deep, rich, and rather moist soil, and in Illinois, tulip trees are found in the southern two-thirds of the state.

Under forest conditions tulip trees are characteristically tall-mature trees that range from 3 to 8 feet in diameter and 90 to 100 feet in height. They lose their lower branches, rapidly resulting in straight, clear trunks. Also, they have a spreading root system with a deep, fleshy taproot and will sprout readily from a stump following a cutting or a fire. The bark on a young tulip tree is smooth and greenish gray; as the tree matures its bark becomes dark gray and is made up of straight, deep furrows with interlacing ridges. The bark is thin and easily damaged. Its twigs are reddish brown and aromatic. The winter buds are a half-inch long, dark red, and covered by two large, flattened scales, giving it the appearance of a duck bill.

Tulip trees have simple, alternate leaves of an unusual shape. These leaves are four to six inches in diameter, smooth-edged and mostly four-lobed with a broad notch at the tip. They are dark green and shiny on the upper surface and paler underneath. During autumn the leaves turn clear yellow. In May and June, after the leaves are fully expanded, the tree produces large, showy tulip-shaped flowers. These flowers are nearly two inches across and are composed of six creamy to greenish yellow petals, often tinged with orange. The fruit is a brown upright, narrow, cone-shaped cluster of winged seeds which will ripen in September and October.

Tulip trees have many different common names, depending on the region where the tree is found and its uses. Its scientific name, *Liriodendron tulipifera*, comes from Greek and means a tree bearing lilies. The resemblance of its flower to a tulip has conferred the name tulip tree. Wood users prefer the name whitewood, while yellow poplar is preferred by lumbermen. While called poplar, it is not correct because the species is a member of the magnolia family. One reason for the poplar misnomer is that tulip tree leaves tremble in the breeze in much the same way as true poplars.

Teachers Guide to Trees in Winter

Once students complete this exercise, see how many of these species they can find outside. Only a few characters are used in this exercise. Obtain a winter tree guide and take the students out to see how many more species can be identified in the school yard. Keep track of your identifications and see if they still agree with their decisions once the leaves come out in the spring.

Students can make a twig collection much the same way they make a leaf collection at other times of the year. They should collect twigs that have at least four buds. These can be pressed in a plant press or a book, and later mounted on paper. The students should take general notes on the description of the tree from which the twig is removed (height, type of bark, how branched) and keep it with the sample.

vocabulary:

buds—growing point of leaves, often covered with protective scales.

twigs—small, fine branch tips.

alternate buds—buds growing singly on the twig, on alternate sides of the twig.

opposite bud—two buds growing at the same height on a twig, but on opposite sides.

Answers to Trees in Winter: 1= b&k, 2=j, 3=f, 4=c, 5=e, 6=d, 7=a, 8=h, 9=i, 10=g

Trees in Winter

The most common character used to identify a tree is the leaf. Since deciduous trees drop their leaves for the winter, this character, unfortunately, cannot be used all year. This does not mean that trees are not identifiable in winter, however. Other characters, such as buds, twigs, and bark, are very useful. There are several species of trees and shrubs that have very distinct characteristics in winter. Try matching the description on the left with the drawings.

1. Beech trees have slender, narrow, sharply pointed buds arranged alternately on the twig. Beech trees also have very distinct smooth, gray bark.

2. Tulip trees have smooth, flattened buds that resemble duck bills. They are arranged alternately on the twig.

3. Sassafras trees have smooth, slender, green twigs, with buds arranged alternately.

4. Flowering dogwoods have smooth, slender twigs with buds arranged oppositely. The flower buds are large, round, and flattened.

5. The dark bark of the sycamore tree flakes away in large pieces exposing large patches of greenish or whitish underbark.

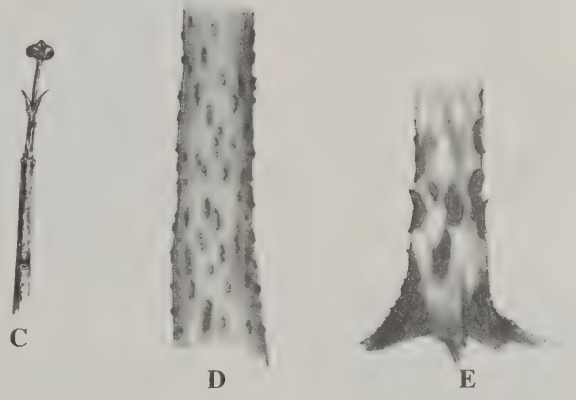
6. The bark on young hackberry trees, and on the upper branches of older trees, appears to be covered with corky "warts."

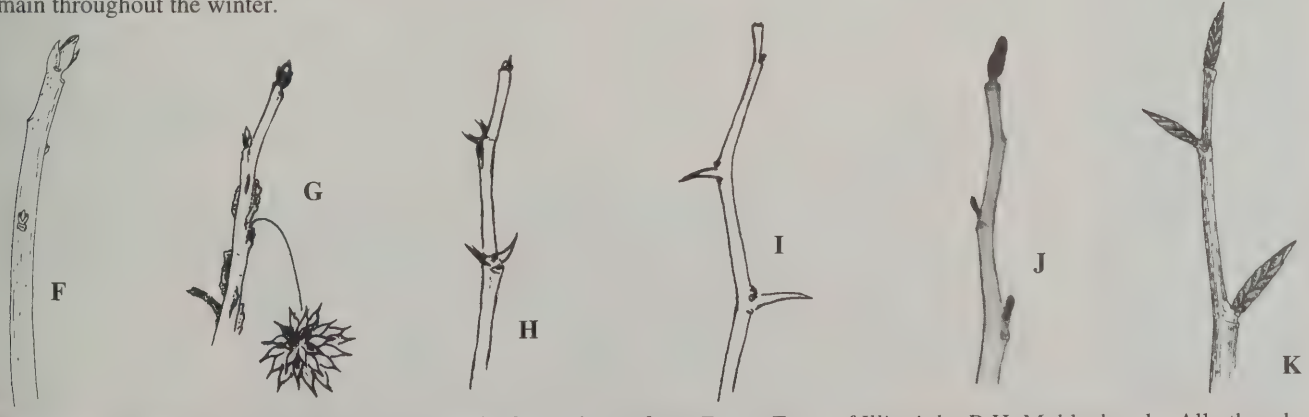
7. The bark of the blue beech, also known as musclewood, is smooth and gray, with ridges that give it a muscular appearance.

8. Black locust trees have a pair of sharp thorns at the base of each leaf bud.

9. Osage orange twigs have a single spine on each alternate bud, and zig-zags from bud to bud.

10. Sweetgum twigs often have corky ridges. The buds are alternate, and sometimes are sticky. One-inch diameter spiny balls (the fruit) remain throughout the winter.





Illustrations of beech twig, dogwood twig, and sassafras twig are from *Forest Trees of Illinois* by R.H. Mohlenbrock. All others by C. Nixon.

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Snakes

continued from front page

were similar to fox snakes in their use of vertical space, except that about 5% of the locations were in vegetation less than 10 feet above the ground. Our telemetry data support the general descriptions given by Philip W. Smith, a former scientist with the Natural History Survey, in his 1961 bulletin *The Amphibians and Reptiles of Illinois*, and they provide the first quantitative data on habitat selection for these species in Illinois.

Although we do not know whether competition for resources influences the behavior of these species, it is interesting to speculate about how differences between species might facilitate their ability to coexist. Our data provide an example of two species in the same genus, black rat snakes and fox snakes, that have similar diets but differ strongly in their use of habitat where they occur together. In contrast, habitat use by fox snakes and blue racers was very similar at the level we examined it. Blue racers seemed to be active on the ground at warmer temperatures, to move more quickly at warmer temperatures, and to move more slowly at cooler temperatures than did fox snakes. Perhaps these species have different thermal preferences. Hatchling fox snakes readily feed on newborn mice whereas hatchling racers refuse mice and prefer insects. Blue racers also do not constrict their prey as much as black rat snakes and fox snakes do, and may be more limited in the size of the prey they can overpower. Perhaps differences in diet reduce competition between these species. The community ecology of snakes would make a fascinating subject for future studies.

We located three hibernation sites, including one site that appeared to be a major center for hibernating snakes. At least five species hibernated at this site, with black rat snakes aggregating there in large numbers. Some snakes migrated almost a mile from this site in the spring to their summer foraging areas, and returned in the fall. We prefer to keep the locations of these sites confidential, as not everyone appreciates snakes for the wonderful creatures they are.

The next time you're out walking in the early spring before the trees leaf out, you might look up to watch for a snake basking in the branches as well as watch out for the ones underfoot.

This project was supported by a grant from the Illinois Wildlife Preservation Fund and Federal Aid to Wildlife Restoration Grant W 125 through the Illinois Department of Natural Resources.

Ed Heske, Center for Wildlife Ecology, and Larry Keller, UI Department of Natural Resources and Environmental Sciences

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ILLINOIS NATURAL HISTORY SURVEY

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Urban Ecology in Illinois

INSIDE

When one thinks of ecology or ecosystems, the first thought to come to mind may be dramatic, sweeping habitats, such as vast stands of tallgrass prairie plants, river-bottom forests of cypress and tupelo, or the rugged ecosystems associated with canyons and bluffs—all places that conjure up the sense of "somewhere else." All three of these habitats can be found within the boundaries of Illinois— the Midewin tallgrass prairie near Joliet, to the Cache River floodplain forests of southern Illinois, to the canyons and bluffs of Apple River Canyon and the Mississippi Palisades. But ecology isn't restricted to pristine habitats or "somewhere else." Sometimes ecology happens in our own backyard or in places that might be unexpected—such as large urban areas.

The greater Chicago area is one such area in Illinois. Encompassing much of the six counties in the northeastern part of the state, greater than 200,000 acres of habitats are protected. Many of these habitats exist in Illinois only within the greater Chicago area, and others are well represented within that array of protected sites. The term "Chicago Wilderness"—a partnership of over 60 public and private organizations—is not an oxymoron. Instead, it reflects the fact that there are thriving areas within the greater urban and suburban setting, sheltering nearly 200 plants and animals that are listed as threatened or endangered in the state, and that numerous organizations in the state care about the ecology of urban areas and the species they contain.

View of Chicago looking north from Calumet Sag Channel toward Loop. **Photo by Michael Jeffords, INHS Office of the Chief**

Sandhill Crane (*Grus canadensis*) in parking lot at Champaign, IL. **Photo by Carie Nixon, INHS Office of the Chief**

Although there are many beneficial ecological interactions in urban and suburban settings, those areas also are often so disturbed that they are prone to ecological problems—whether the disappearance of habitats or degradation of them due to human activities, or just the proximity of urban areas to other habitats. For example, aquatic areas near cities are home to mosquitoes that can carry diseases, such as West Nile encephalitis that occurred in New York last year. Disturbed urban forests and aquatic habitats have been ripe for invasions by exotic plants, such as garlic mustard or purple loosestrife; exotic aquatic organisms, such as round gobies and zebra mussels; or exotic insects, such as Asian longhorned beetles or gypsy moths. Invasions of urban areas are not limited solely to exotic species: our backyards, forest preserves, and other green areas have been invaded by more familiar species, such as Canada Geese and white-tailed deer.

In this issue of *Illinois Natural History Survey Reports*, we highlight ongoing INHS research and outreach projects that can be collected under the umbrella of "urban ecology." Survey scientists from all disciplines are studying the interactions of plants and animals in urban and suburban habitats. The studies reported here range from particular species to habitats to entire ecosystems. The report on energy and resource use and the "ecological footprint" of urban areas illustrates a crucial concept for long-term urban planning and "smart growth" of our state. A report on the wise and perhaps paradoxical development and

Continued on page 11

Lake Calumet—The Dream of Recovery

The Lake Calumet region, located at the southwestern tip of Lake Michigan, once was one of the premier biologically diverse sites in Illinois. Presettlement habitats included extensive wetlands, dunes, swales, lakes, and some forested areas. Beginning in the mid-1800s, Great Lakes shipping increased and industrialization (manufacturing and processing of steel, brick, tile, sand, gravel, petroleum, and meat) and associated urban development began what would eventually become major modification of the area habitat. Wetlands were filled and replaced with industrial sites, homes, and landfills. In spite of this abuse, this area contains the richest remnant natural areas in the city of Chicago, and for these areas there are dreams and plans.

Fifteen significant wetlands and natural areas are listed in "An Open Space Plan for Chicago," completed in 1997. For these sites this integrated regional plan recommends their protection and enhancement, development of a habitat management plan for each, and their promotion as an essential component of an overall economic development plan for the area. The sites are Big Marsh, Deadstick Pond, Heron Pond, Hyde Lake, Migrant Bird Trap, Turning Basin Wetland, Calumet River, William Powers Conservation Area, Eggers Woods Extension, Eggers Woods Forest Preserve, Indian Ridge Marsh, Lake Calumet, Railroad Prairie, and Van Vlissingen Prairie.

Indian Ridge Marsh. **Photo by David Voegtlin, INHS Center for Biodiversity**

At one of these sites, Indian Ridge Marsh, the city of Chicago plans to build an environmental center that houses both interpretive exhibits as well as space for outreach personnel and research scientists. Emphasis at this site would be on rehabilitation and remediation, education, and urban environmental research. Traditional and new processes for site cleanup will be tested, including phytoremediation (the process of growing plants that biologically remove or degrade contaminants from water and soil), hydrological modifications for cleaner water, plantings on industrial fill (mostly slag), and using biological control to manage invasive exotic species like purple loosestrife.

Lake Calumet near Chicago. **Photo by David Voegtlin, INHS Center for Biodiversity**

The city of Chicago has designated an industrial corridor within the Calumet region to focus on economic development and job retention. This corridor is to be a model for environmental remediation as a partnership between the business and residential communities.

In addition, a Calumet National Heritage Area has been proposed by the Calumet Ecological Park Association for an area extending from Indiana Dunes National Lakeshore on the east to the Illinois and Michigan Canal National Heritage Corridor on the west. This designation would preserve both the natural and cultural heritage in ways that meet the economic needs of the present generation while preserving the area's unique natural resources for future citizens. A feasibility study on this proposed National Heritage Area was conducted by the National Park Service and released in 1998.

There is enormous interest in the Calumet area and the potential it holds—if given some tender loving care rather than abuse. Involvement and support of all those with interests in the region, from industrial concerns to the local property owners, as well as recreational interests and local, state, and national governments, are critical to the eventual success of the recovery efforts. This process will not be easy because of the diverse array of interests as well as the degraded conditions of many of these remnant habitats. However, the process has begun and, with broad support, will continue to gather momentum.

One of the amazing aspects of natural systems is their resiliency; and some of the remnant habitats in the Calumet region, such as Powderhorn Lake, that have received care and attention in recent years have shown remarkable improvement. If Powderhorn Lake is an indication, there is a great deal of promise in the Calumet region, and if only some of the dreams for it come to pass, it will once again be a biologically remarkable place.

David Voegtlin, Center for Biodiversity

Research and Outreach Try to Stem Tide of Exotic Invasions in Lake Michigan

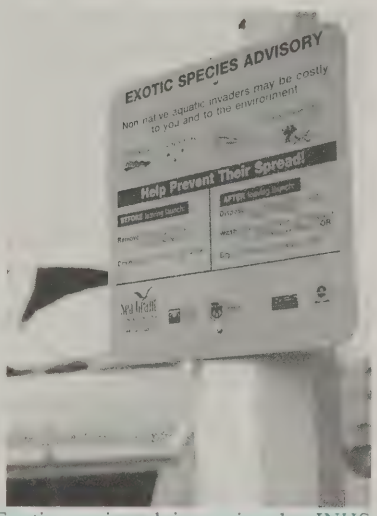
Since the early 1800s, over 140 exotic species have invaded or been introduced into the waters of the Great Lakes basin. In most cases, these introductions have occurred as a result of human activities including shipping, building of canals, and deliberate releases. Several of these species have had substantial impacts on the Great Lakes resource. For example, the sea lamprey was responsible for the disappearance of Lake Michigan's lake trout populations, which now are maintained in the lake only through stocking. Millions of dollars are required annually to manage, control, and reverse the impacts of nonindigenous aquatic nuisance species in the Great Lakes.

Many of these species first introduced into the Great Lakes have been transferred to inland lakes, rivers, and streams both near to and far from the Great Lakes. Often this transfer is a direct result of human activity such as the building of canals. The Chicago area canals built to allow reversal of the flow of the Chicago River have enabled two recent invaders, the round goby and the zebra mussel, to move downstream from Lake Michigan into the Illinois and Mississippi rivers, respectively. The Illinois Natural History Survey is working with a panel of municipal, state, and federal entities in the design of an experimental barrier intended to curtail the downstream movement of species from Lake Michigan into the Illinois River (and vice-versa). The first phase of this barrier will be installed by the Army Corps of Engineers in the summer of 2000. Subsequently, researchers at the Survey's Lake Michigan Biological Station will begin studying the ability of fish to move across the barrier, which will provide insight into the feasibility of barriers as deterrents to the spread of exotics.

The round goby (*Neogobius melanostomus* Pallas). **Photo by INHS Lake Michigan Biological Station staff**

Recreational boating and fishing are other mechanisms by which exotics are spreading to inland waters. For example, six lakes in the greater Chicago area have been confirmed as infested with zebra mussels, which most likely were introduced into these lakes on boats or boat trailers used previously in infested waters (e.g., Lake Michigan). Likewise, the round goby has been introduced from the Great Lakes into two inland rivers in Michigan, most likely as a result of an angler using them as bait. These exotics can cause a myriad of problems (e.g., food web disruption, reduced biodiversity, clogging of water intakes, increased weed growth), and cannot be eliminated from a system without causing increased harm.

A statewide survey of boaters and anglers to determine their knowledge and attitudes regarding exotic species indicated that this group lacked information on the potential spread of exotics via fishing and boating activities and equipment. Therefore, with funding from the Illinois-Indiana Sea Grant College Program and the Great Lakes National Program Office of U.S. EPA, we have initiated several outreach projects targeted at boaters and anglers. Also, we have produced large metal "Exotic Species Advisory" signs for placement at boat landings around the Illinois shoreline of Lake Michigan. These signs caution boaters about the potential impacts of exotics, and encourage boaters to take the necessary steps (e.g., washing the boat before traveling to another waterway) to prevent accidental spread of these species. We have produced a brochure for boaters containing background information on exotic species and steps for preventing their spread. We then made these brochures widely available to the boating public through venues such as boat shows and safe-boating classes sponsored by the Illinois Department of Natural Resources. We have also developed displays for baitshops that assist anglers in identifying the round goby. A preliminary survey of anglers in the Chicago metropolitan area indicated that 45% of anglers cannot distinguish the round goby from a common native species. This confusion could contribute to anglers unknowingly spreading the round goby. Sea Grant also has funded a project that involves providing baitshops with baitbucket stickers. These stickers will remind anglers not to release unused bait into a lake or river, because that can result in non-native species (e.g., Eurasian watermilfoil) becoming established. We hope that these outreach projects combined with the experimental dispersal barrier will advance the campaign to prevent the spread of exotic species from Lake Michigan to inland Illinois.



Exotic species advisory sign that INHS helped develop to encourage boaters to take precautions to prevent spread of exotic invaders. **Photo by Patrice M. Charlebois, INHS Center for Aquatic Ecology**

Patrice M. Charlebois, Center for Aquatic Ecology

Plant Stress—Its Relationship to Arthropod Pests in Urban Landscapes

Trees and shrubs are important components of urban landscapes because they increase the aesthetic value of any property. Properties that contain an assortment of trees and shrubs are more likely to sell faster than properties that contain no trees or shrubs. In addition, the presence of a diversity of trees and shrubs may provide refuge for animals such as birds, rabbits, and squirrels.

Unfortunately, trees and shrubs growing in urban landscapes are subject to a variety of stress factors that may increase their susceptibility to insects and other opportunistic arthropod pests. This generally involves plants located in residential and commercial landscapes. However, it also includes plants located along streets, walkways, and in shopping center parking lots where they are surrounded by asphalt or concrete ("hardscapes").

Plants that are growing along streets and walkways are subject to pollutants from automobile exhausts and dust. This may not only increase plant stress, but may also reduce the abundance of natural enemies (beneficial predators and parasitoids) because dust has been shown to be detrimental to the natural enemies. The absence of natural enemies may result in plants experiencing higher populations of arthropod pests. In addition, plants growing near streets and walkways are susceptible to disturbance, especially construction such as walkway replacement and repair or the installation of new piping. This generally results in severe root injury, which can compromise the ability of plants to defend themselves and increase their susceptibility to arthropod pests.

Another factor that may lead to increased plant stress is the amount of hardscape, such as parking lots and buildings, surrounding plants. An increase in heat absorption, light reflection, or an inadequate water supply may create a microclimate that is stressful to plants. This environment may be conducive for pest development and deleterious to natural enemies. In addition, plants located in these isolated microclimates may also make it difficult for natural enemies to find pests.

Plants growing in residential or commercial landscapes are subject to stress factors from mechanical injury and improper cultural practices. Mechanical injury can occur when lawn mowers or weed-whackers are used to trim turfgrass growing along the base of trees or shrubs. Lawn mowers or weed-whackers may inadvertently remove bark (cambium) tissue and girdle plants, creating plant stress and increasing susceptibility to wood-boring insects. Proper cultural practices can reduce a plant's susceptibility to wood-boring beetles; however, improper use of irrigation, fertilizers, or mulches may alter the host-pest balance in favor of the pest.

Over- or underwatering can create a series of physiological changes that lead to plant stress and greater opportunity for insect attack. Plants stressed from overwatering may result in more resources allocated toward growth and fewer resources allocated toward defense, which makes it easier for opportunistic insects to attack plants. Underwatering may also lead to stress because plants are unable to take up enough water to maintain normal metabolic functions. Wood-boring beetles and other insects take advantage of this situation. It has been demonstrated that plants under water stress are unable to produce oleoresins, which normally act to repel beetles. Pine trees, for example, were more susceptible to pine bark beetles during periods of water stress.

The use of rapid-release fertilizers, such as those used for turfgrass, may increase a plant's susceptibility to piercing-sucking insects such as aphids, leafhoppers, and scale. Overfertilization results in insect problems because plants may allocate more energy into growth and less into defense. The level of chemical defenses necessary for resistance to insects decreases in rapidly growing trees. For example, birch (*Betula* sp.) and quaking aspen (*Populus tremuloides*) are more susceptible to leaf-feeding insects when fertilized. In addition, this often leads to the production of soft, succulent growth that has higher amounts of protein and a thinner cuticle that is easier for aphids, mites, and leafhoppers to penetrate with their mouthparts.

Urban tree being stressed by a number of environmental factors including loss of roots, soil compaction, burial of crown under gravel, and encroachment by hardscape.
Photo by Raymond Cloyd, University of Illinois

Proper mulching can lead to healthy plants due to a reduction in weed competition, higher soil moisture retention, and prevention of damage to the base of trees and shrubs from lawn mowers and weed-whackers. However, too much mulch or mulch that covers the plant crown (base) can cut off oxygen and suffocate plants.

Research at the Illinois Natural History Survey, the University of Illinois, and in other midwestern states is evaluating the impact of plant stress on susceptibility to arthropod pests. This will continue to be an important research consideration as suburban expansion and development proceed at an accelerated pace.

Raymond A. Cloyd, UIUC Department of Natural Resources and Environmental Sciences

Environmentally Friendly Gardening

Gardening is a significant outdoor activity of many urban and suburban homeowners. In fact, over 67% of American households have gardens. For many urban and suburban residents, lawns and gardens may represent the closest green space available to them. But urban gardens contain more than green plants, flowers, and vegetables: home lawns and gardens also have numerous insect pests, weeds, and plant diseases, many of the same kinds that affect farmers throughout the state.

A garden thriving without the use of chemical pesticides but with biologically based strategies for pest control. **Photo by Robert O'Neil, Purdue University**

To combat these pests, most urban and suburban homeowners respond by applying pesticides. Although homeowners may feel the use of pesticides in their own yard and garden is only of minor significance, collectively homeowners spend over $11 billion per year on pesticides. Pesticide use on home lawns and gardens, on a per-acre basis, actually exceeds the use of pesticides in agricultural crops. Gardeners made aware of these facts want to replace use of chemicals in their yards and gardens with biologically based tactics. Knowing about alternatives could reduce household pesticide use dramatically, but the average gardener is unaware of alternatives or how to use them. Unfortunately, many alternative approaches have taken the form of "snake oil," being either anecdotal or untested solutions.

We tackled this problem head-on. In a joint project between entomologists at the Illinois Natural History Survey and Purdue University, we developed a training and research program for Illinois and Indiana gardeners, teaching about alternatives to pesticides and biological control tactics to use in home yards and gardens. To date, we have taught over 250 Master Gardeners about pests, natural enemies (predators, parasites, and diseases of pests), and biological control tactics that can be used in their gardens. During workshops held in cities in both states, we surveyed gardeners to learn about their current pest management practices, use of pesticides, and awareness of alternatives. Gardeners were then re-surveyed after one year to see if they altered their practices as a result of the training.

We found that training gardeners about biological control and alternatives to pesticides greatly affected their use of pesticides and alternative tactics. Before training, 63% of all gardeners relied mostly (using them either always or usually) on using insecticides against insect pests. One season later, only 28% of gardeners relied mostly on insecticides (Fig. 1). Many gardeners totally quit using pesticides—42% of gardeners used no conventional insecticides after training, versus only 15% of gardeners who used no conventional insecticides before the training workshops. Others increased their use of alternative tactics, such as companion plantings and mulches.

Reducing pesticide use in the home garden is one benefit of the program. Still another is developing alternatives for gardeners' pest problems. We taught gardeners about conducting research and helped them to become "volunteer researchers," testing potential biological control tactics, using their ideas and their gardens as test plots. We wanted the experiments conducted scientifically to see if the tactics worked and we could make recommendations to other gardeners. Gardeners conducted four research projects with our guidance and support: releasing *Trichogramma* wasps weekly against larvae of cabbage butterflies; comparing the numbers and kinds of predators caught in pitfall traps situated in mulched and unmulched potato plots; testing to see if spraying sugar water onto tomato plants attracted or retained predatory ladybird beetles; and spraying beneficial nematodes onto iris plants to combat iris borer.

Two of the volunteer research projects had enough participants to yield useful results. Gardeners who released tiny (< 1/64-inch-long) *Trichogramma* wasps weekly reduced levels of cabbage worms greater than fivefold in 1998: from an average of 0.59 caterpillar larvae per cabbage plant where no wasps were released to 0.11 larvae per plant with wasp releases (Fig. 2). However, in 1999 no similar pattern was seen because numbers of cabbage worms were below pest status. Control plots had 0.12 larvae per plant, versus 0.10 larvae per plant with releases. Thus, although

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releasing wasps could reduce the cabbage worm numbers from pest to nonpest levels, the wasps could not reduce numbers of cabbage worms when they were already low. Further, weekly releases of wasps cost more than gardeners were likely to pay (about $50 per season). Further tests will be conducted to see if we can reduce the number of releases, start later in the season, or quit sooner to make the tactic less expensive. Gardeners also found that spraying their iris beds with nematodes in early May reduced the damage from an average of 24% of rhizomes with iris borer damage to 34% of rhizomes with damage in control plots. Spraying nematodes later in the summer, when soil temperatures were higher, had a greater effect. Where nematodes were applied in June, only 11% of rhizomes had evidence of boring by iris borer compared to 24% damaged rhizomes in control plots. This tactic will be pursued again in 2000 to see if the results hold true. The pitfall trap and sugar water experiments did not show any differences between treated and control plots, though small numbers of plots may have affected the results.

The real test of the project's success will be the expansion over the next few years. We showed that gardeners trained in biological control adopted practices to reduce their use of insecticides. Simple education about biologically friendly alternatives greatly changed the gardeners' behavior. Greater adoption of biological control and non-chemical pest management alternatives will help keep urban gardens green—and friendly to the gardeners.

Robert N. Wiedenmann, Center for Economic Entomology; Clifford S. Sadof and Robert O'Neil, Purdue University

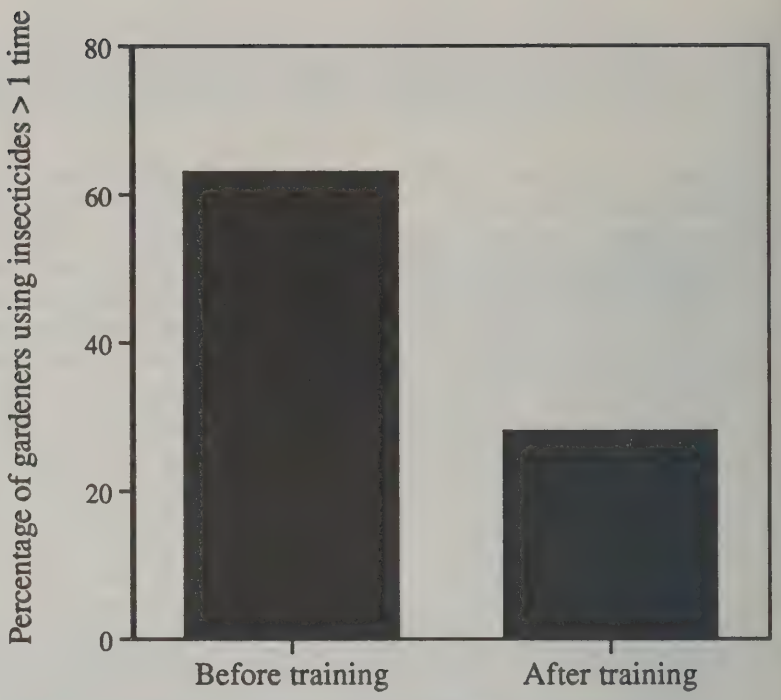

Figure 1. Percentage of gardeners using insecticides more than once per season, before and after training in biological control.

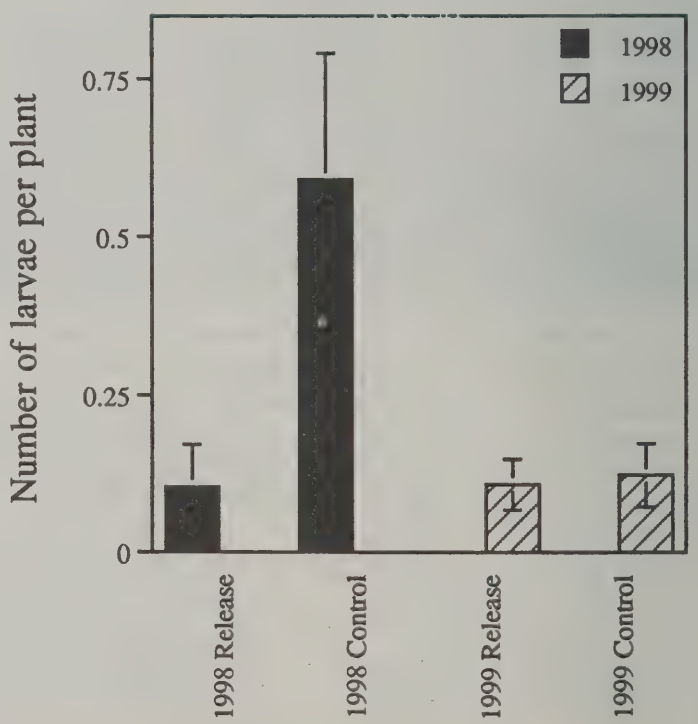

Figure 2. Numbers of cabbageworm larvae per plant, with and without releases of *Trichogramma* wasps, in 1998 and 1999.

Insect Invaders Infest Chicago Trees

The Forest Preserve Districts of Cook and DuPage counties afford Chicago residents and visitors alike a touch of wilderness amid the towering skyline and bustling thoroughfares of the city. In fact, last year more people used Cook County's forest preserves than visited Yellowstone National Park. But a most unwanted visitor, the Asian longhorned beetle, also finds these 90,000 acres of preserve and the 500,000 trees lining the streets of the city of Chicago quite appealing.

The first Illinois infestation of the Asian longhorned beetle was discovered in the Ravenswood neighborhood of Chicago in July 1998. Soon to follow were detections of much smaller infestations in Addison (DuPage County) and Summit (southern Cook County). Illinois' battle with the Asian longhorned beetle had begun.

Survey crews armed with binoculars were quickly dispatched throughout the neighborhoods in search of infested trees, but authorities soon learned that ground searches alone were inadequate. The telltale signs of infestation, dime-sized adult exit holes or the much smaller egg-laying sites, were often well concealed and high in the tree canopies. In March 1999, bucket trucks and tree climbers (mostly U.S. Forest Service smoke jumpers) were added to the arsenal of survey tools and many more infested trees were identified. Regrettably, removal and destruction of infested trees are currently the best tools available to eliminate and control the Asian longhorned beetle. Since the damaging larval stage lives deep inside infested trees during most of the year, conventional insecticide sprays are not an option, and lures are not available to attract adults.

Tree-cutting operations began in the Ravenswood community in February 1999. Within a matter of days, 837 trees were felled, chipped, and burned. Portions of the once tree-lined streets of Ravenswood were suddenly barren and the onslaught continues. An additional 314 infested trees were discovered during intensive survey efforts in 1999, while 54 trees were felled in Addison and 24 succumbed in Summit. Although residents were not held responsible for the cost of tree removal, their losses were immeasurable. What is the value of a tree in the city? A mature city tree not only provides beauty but also offers many practical benefits such as summer shade; winter wind protection; reductions of air, water, and noise pollution; natural habitats; and increased property values. But to many, the emotional loss was perhaps the most profound; an old friend was no longer there to greet them each day.

Even so, residents agreed to these heroic measures in hope of preventing a similar fate for other neighborhoods or the beloved parks and forest preserves of the city. More than 11% of Cook County is a forest preserve and the majority of trees are acceptable hosts for Asian longhorned beetle. According to city foresters, 50% of Chicago's trees are maples, which happen to be one of the beetle's favorite foods, and overall 70% of the city's trees are susceptible. Clearly, the potential for a replay of the Dutch elm disease disaster of the 1950s (which coincidentally also struck the Ravenswood neighborhood) is a possibility.

With this in mind, the selection of trees for replanting has been done with extreme care. A variety of oaks and lindens, catalpa, Kentucky coffeetree, Turkish filbert, gingko, tulip tree, and honey locust have been chosen to replace those sacrificed to the Asian longhorned beetle. Our current knowledge of the beetle's host range suggests that these replacement trees are resistant to Asian longhorned beetle attack. City foresters began replanting operations during summer 1999 with balled and burlapped trees up to 18 feet tall, again at no cost to homeowners. Still, it will take many years of tender care before the replacements can hope to once again rise above the rooftops. Throughout this process of regrowth, landscapes may well dramatically change—an ecological succession of sorts. For instance, shade-tolerant shrubs, flowers, groundcovers, and vines that once thrived in canopied yards will face much stronger summer sun and may not survive. In some cases, this may require periodic replacement of understory plantings as the tree canopies gradually grow denser.

Trees in the Ravenswood neighborhood of Chicago were cut down as a result of damage by invading Asian longhorned beetles. **Photo by Michael Jeffords, INHS Office of the Chief**

The city's struggle with the Asian longhorned beetle continues. Although adult beetles were difficult to find in 1999 and far fewer infested trees were located, regulatory officials are far from saying the battle is won. Fortunately, the Asian longhorned beetle is not a particularly strong flier and does not appear to be rapidly expanding its range; however, several new spot infestations were found outside the quarantine boundaries, including four trees in a forest preserve. Intensive surveys and tree removal will likely continue for five or more years at a cost of several million dollars before we will know with certainty if eradication attempts are successful and the Asian longhorned beetle becomes a distant memory. But residents of affected neighborhoods will get a daily reminder of the impact of this conflict for many years to come—just by looking out their windows.

Charles Helm, Center for Economic Entomology

Cities and Ecological Dependence

A basic ecological problem of cities (as opposed to problems *in* cities) is their dependence beyond their borders for energy, water, minerals, food, and other necessities, and for assimilation of their wastes. The "sustainable city unit" therefore should include not just the acreage of cities and their suburbs but also the ecologically productive land anywhere on the globe that support it. "Ecological Footprint," developed by planners Mathis Wackernagel and William Rees at the University of British Columbia, is a vivid descriptor of this dependence.

Such footprint calculations, though based on many arguable assumptions, indicate that at urban, national, and global scales, humans have ecological footprints exceeding available land. The ratio of footprint to actual area is of order 100 for industrialized cities, 10 for developed countries (notable exceptions: Canada and Australia, which, though rich, are sparsely populated), and 2–3 for the entire human race.

Unless wildly incorrect, these results imply that present activity is unsustainable and that we are likely in an overshoot period preceding a decline in productive life-support. Given that there are now worldwide 345 cities of more than a million inhabitants, with 527 projected in 2015, this growth is dire. Yet it also offers impetus to design and execute more sustainable societies, and the details offer points of improvement (particularly in water and energy). Typically the issue of dependence in a finite world is the last bastion of denial about human impacts. Acting locally to address the larger problem is difficult, as planners will admit. If dependence were a serious factor in urban planning, cities could have smaller footprints, and the sizes and distribution of urban concentrations would be different. In economic terms, city life would cost more than it does today, and the urbanization trend would not be as rapid.

Dependence, along with depletion (of resources) and disturbance (of natural flows and cycles) comprise the 3 Ds, a set of indicators Todd Wildermuth and I use to evaluate the environmental sustainability of agricultural practices and agriculture-based communities in Illinois and Kansas. In Chase County, KS, we find, not surprisingly, that in terms of energy and nitrogen, land used for raising range-fed beef has lower dependence than land in row crops, as shown in Table 1. In addition, Chase County exports crude oil and natural gas, yet imports all the refined petroleum and natural and bottled gas it burns, and hence has both high depletion and dependence for energy.

I am now designing research with planning faculty members to calculate, and to use in actual planning practice, these indicators for smaller Illinois cities. The typical question is how more efficient use within the city will reduce beyond-boundary requirements. This includes use of water and energy, recycling of packaging, design of buildings and transportation systems, promotion of local agriculture, and provision of green space.

Robert A. Herendeen, Center for Aquatic Ecology

Resource	Depletion (yr^{-1})	Static lifetime (yr)	Dependence	Disturbance	
				Input form	Output form
Soil, grazed land[A,B,C]	3.17×10^{-4} to -2.75×10^{-5}	3200 to _	0	0	0.4
Soil, ungrazed land[B]	1.17×10^{-3} to 1.41×10^{-3}	580 to 710	0	0	6.5
Water	0	_	0	0	0
Oil	0.04	25	1	2.55×10^{-5}	_
Gas	0.07	14	1		
Nitrogen, grazed land[D]	2.88×10^{-4} to -5.12×10^{-2}	3470 to _	0	NA[E]	NA[E]
Nitrogen, ungrazed land[D,F]	-1.4×10^{-2}	_	0.59	12	9.1

Table 1. Summary chart of indicators for Chase County, KS soil, water, energy, and nitrogen resources. Depletion is the ratio of the drawdown rate divided by the stock and has the units of 1/time. The inverse is the static lifetime: how long nonrenewable resources will last at today's deletion rate. Disturbance is (today's flow)/("natural" flow) - 1. Dependence is import/internal use. All three D's are thus 0 for the nondepleting, undisturbed, independent ("self-sufficient") case.

A. Soil includes only the A horizon, which is treated as a homogeneous unit.

B. Grazed land includes range, pasture, and grazed forest. Ungrazed land includes row-cropland and towns.

C. Given as a range due to the uncertainty in rates of soil formation.

D. Given as a range due to the uncertainty in fixation by prairie vegetation.

E. Details of long-term nitrogen cycling are unknown.

F. Assumes the same stock of nitrogen as grazed lands.

Urban Conservation of a Wetland Bird Species

In spite of the loss of many of northeastern Illinois' presettlement wetlands, a large number of wetlands remain in this highly urbanized and rapidly developing region. These wetlands are home to significant populations of wetland birds. These include colonial species, such as Great Blue Herons, American Egrets, Double-crested Cormorants, Black Terns (Illinois endangered), and Black-crowned Night Herons (Illinois endangered), as well as species with dispersed distributions, such as Pied-billed Grebes (Illinois threatened), Common Moorhens (Illinois threatened), Least Bitterns (Illinois endangered), and Yellow-headed Blackbirds (Illinois endangered). A major impediment to the conservation of these species and their wetland habitat is a general lack of information regarding the population dynamics and habitat requirements of these species in urban environments. This paucity of information makes long-term planning for conservation, development, habitat mitigation, and habitat restoration extremely difficult.

Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). **Photo courtesy of Vic Becario**

Our research is currently focused on one species, the Yellow-headed Blackbird. This species was an abundant resident in the southwestern Great Lakes region a century ago. Since that time, however, its population has declined precipitously and Yellow-headed Blackbirds currently persist in small numbers in only a few populations east of the Mississippi. One of the largest of these populations is in northeastern Illinois, in the marshes of Cook, Lake, and McHenry counties. However, these marshes are under constant development pressure, and the Illinois Yellow-headed Blackbird population has continued to decreased at an alarming rate over the past 20 years (approximately 8% per year; Illinois Department of Natural Resources data).

We have been studying the northeastern Illinois population of Yellow-headed Blackbirds for the past two years in order to identify factors contributing to its decline, document whether individuals from this population return to the area annually, describe the movements of individuals among the marshes of the region, and describe the population trend and age structure. Our long-range goal is to gather the information required to develop a conservation plan that will ensure the survival of the Yellow-headed Blackbird in northeastern Illinois and in the southern Great Lakes area.

To date we have marked over 200 individual birds, establishing that adults breeding in one year are very likely to return to the area to breed again. We also found that these birds can and do successfully breed in close proximity to human development, provided that their marsh habitat remains intact. In addition, we found that nesting and fledgling success over the two-year period was relatively high, suggesting that the population is producing enough young to remain stable.

So why is this population declining, and why has this population, isolated by hundreds of miles from the large western populations, persisted? A longer period of investigation will be required to answer these questions. Declines may be solely due to the loss of habitat, in which case protection of sufficient marsh habitat may be all that is required to ensure the persistence of the species in Illinois. On the other hand, large-scale demographic factors may be partially responsible for the decline. As is the case with many migratory songbirds, young produced in one location seldom return to breed in the same area. Because the Illinois population lies hundreds of miles from the center of the species' range, it is possible that young birds looking for a place to settle seldom find the area. Like humans in a small rural town, the young that are produced there tend to move to the larger (bird) population centers and the population dwindles for lack of new recruits.

Clearly, this species is capable of co-existing with humans in urban and suburban Illinois. We are continuing to monitor the population of eastern Yellow-headed Blackbirds of northeastern Illinois in the hope of understanding what will be required to safeguard the remnant of this species.

David A. Enstrom and Michael P. Ward, Center for Biodiversity; James Herkert, Illinois Endangered Species Protection Board

Cost and Controversy in Managing Urban Deer

Unlike deer in rural Illinois and other parts of the country, urban deer are not regulated by large predators or hunting, thus they often reach extreme population levels in remnant urban natural areas. Deer-vehicle collisions in urban areas are an index of population trends for urban deer. From 1981 to 1992 the number of deer-vehicle collisions increased from 266 to 1,300, respectively, in the three Chicago metro counties (Cook, DuPage, and Lake). Roads adjacent to natural areas also may show unacceptable levels of dangerous car-deer collisions. In addition, intense herbivory associated with high populations threatens the biodiversity of palatable native plants and causes costly damage to ornamentals. To address these problems, managers are faced with the unhappy task of reducing deer populations.

In urban forest preserves, culling deer (using trained sharpshooters in highly controlled situations) is usually the only way to safely and efficiently reduce a deer population. Other methods (sterilization, contraception, trap and transfer) are being researched actively but will not work currently because of prohibitively high costs and severe logistical problems.

An additional complication in urban deer management is that per capita reproduction is density-dependent, meaning that the average number of fawns produced and reared by each doe increases as the total population decreases. This is analogous to having a bank account where the interest rate (reproduction) is a declining function of the account balance (population size). Maximum return (number of new recruits in the next breeding season) is thus achieved at some intermediate account balance where a declining balance and increasing interest rate is optimized. Similarly, deer reproduction increases as managers begin to remove deer, thus requiring managers to work ever harder to reduce the deer population to offset the population's increasing reproductive effort.

For several years, the DuPage County Forest Preserve District has had a progressive deer management program that is beginning to enhance conservation efforts on the native vegetation of preserves where culling is done. Culled deer are processed, inspected, and donated to Chicago area charities. We have been examining the reproductive tracts of culled deer and with other field data we have been identifying the life history mechanisms behind density-dependent reproduction.

White-tailed deer, a very common inhabitant of Illinois urban and suburban areas.
Photo by Tim Van Deelen, INHS Center for Wildlife Ecology

Examination of over 550 reproductive tracts from a period of six years of intensive removal effort suggested that pregnancy rates for adults and yearlings remained high (89%). Pregnancy among fawns (indicating conception during the first breeding season) varied from 0 to 25% as population density decreased. Fawn mothers always gave birth to single young whereas older does tended to have twins. In addition, the fecundity of older does increased slightly with decreasing density, and we recorded several mothers with triplets. The most dramatic effect was seen in the number of female fawns that showed up six months later during the population's breeding season. This measure, known as recruitment, increased dramatically with decreasing density. Taken together, the reproduction and recruitment data suggest that the principal mechanism behind density dependence is fawn survival. In other words, the trade-off for maintaining high deer populations is high mortality among newborn fawns.

Fawn mortality is the topic of an ongoing research project, but probably is due primarily to predation by coyotes, dogs, and small carnivores. Secondary causes may include disruption of the mother-fawn bond due to crowding and a limited number of secure fawning sites.

Finally, as if the problems caused by density dependence weren't bad enough, the effort and cost required to cull an individual deer probably increases exponentially as population density declines. Therefore, the need to work ever harder, coupled with the fact that cost increases rapidly as deer density declines, may determine the real-world limits to maintaining deer at reduced population levels. In remnant urban natural areas, conservationists concerned with the negative effects of herbivory may need to accept sustained intense management of resident deer populations.

Timothy R. Van Deelen and Dwayne R. Etter, Center for Wildlife Ecology

Urban Ecology

continued from front page

restoration of wild and natural areas in the Calumet area of southeastern Chicago illustrates how once-maligned and abused habitats can remain vital and even be restored, as long as they are not paved and fragmented.

Northeastern Illinois is the remaining stronghold in the state for the endangered Yellow-headed Blackbird. Suburban housing and office-park developments with appropriate wetlands may provide significant habitat for this colorful avian marsh dweller. Other wildlife, such as white-tailed deer, have benefited from the extensive urban forest preserve systems, vastly increasing deer populations. As reported here, deer can cause habitat degradation and even harm to humans by colliding with autos and by hosting the tick vectors of Lyme and other human diseases. Yet, controlling deer populations in an ecologically sustainable manner brings habitat managers into conflict with urban humans.

The extensive aquatic areas near urban habitats—many urban areas are situated on lakes or rivers due to trade—provide environmental recreation, but also potential environmental nightmares due to exotic invaders. The invaders also threaten the extensive urban forest, as the article about Asian longhorned beetles attests. Even landscape plantings and home gardens are subjects of ecological studies and outreach—studies that can enhance the health of landscape plants that provide shade and other benefits to homeowners and outreach that teaches gardeners about ways to reduce use of pesticides in their own backyards.

While this issue may seem to vary from the usual presentation of studies of wild and natural places in Illinois, we hope you recognize that these ongoing research and outreach efforts are valuable additions to the understanding of an increasingly significant part of the Illinois landscape. Far from oxymoronic, the issue of urban ecology is alive and an important part of the Survey's mission, and crucial to the wise use of the state's natural resources.

Robert N. Wiedenmann, Center for Economic Entomology

Illinois Wilds Institute for Nature (IWIN)

A small group of people huddle with their faces close to the ground, diligently using field guides in an attempt to identify a species of alpine wildflower. The botanist instructor assists with subtle hints and suggestions. The backdrop is the soaring peaks of the Grand Tetons.

Nearby in Yellowstone National Park, another group threads its way single file through a back-county geiser basin. Their guide, a geologist, speaks of the marvels and intricacies of the unique thermal features.

Rising from still water carpeted with several species of duckweed, ancient cypress trees stand as silent sentinels. Frogs leap from floating logs, Prothonotary Warblers flit overhead while a black rat snake makes its way slowly down a massive cypress. The group is spread out along the boardwalk, observing, writing, photographing, and slowly unravelling the ecology of this unique area.

Do any of these scenarios sound interesting? What are they?, you may ask. The first two are long-standing courses offered to the general public at institutes housed at two of the most charismatic national parks; the third is based, believe it or not, in Illinois and will be one of the courses offered by a new program of the Illinois Natural History Survey and the University of Illinois Department of Natural Resources and Environmental Sciences (NRES). Called the Illinois Wilds Institute for Nature (IWIN), the newly formed organization will offer classes on a variety of topics associated with Illinois ecology, natural history, and natural resources. Occasional course offerings may venture from the state's boundaries, but the main focus will be Illinois. IWIN began its official operation on February 1, 2000, and its first course offerings will be during late spring/summer, 2000.

General Information on IWIN

IWIN will be similar in structure to the outreach programs offered by the Yellowstone, Teton, and Great Smoky Mountain Institutes. Natural History Survey biologists and NRES faculty will offer short courses for the general public, teachers, professional individuals, and students of all ages. Each course will have an associated fee that covers the cost of materials, lodging and meals (for residential courses), and other expenses. For some of the courses, college credit will be an option.

Individual courses may include classroom work, field trips, field projects, or other skill-building activities. For many courses, in- or out-of-state field trips will be included. Courses will be offered in a variety of venues, including evening, 1/2 day, 1 day, 2 day, 4 day, or longer. Shorter courses will deal with a specific topic (e.g., butterflies), while longer courses may take an integrated approach to a topic or issue (e.g., Ecology of Southern Illinois). Longer courses may be residential at sites in Champaign, across the state (e.g., Dixon Springs Agricultural Experiment Station), or at selected out-of-state sites.

Separate offerings of IWIN courses will be targeted toward (but not limited to) teachers, students, resource professionals, and the general public. Course offerings will occur at times when audiences are most available—evenings, summer, the break between Christmas and New Year, spring break, etc., or on a periodic basis throughout the year. Each year, a number of courses will be offered and will vary from year to year, depending on interest and demand.

For more information on the Illinois Wilds Institute for Nature and for course offerings for the coming year, please contact the registrar, Susan L. Post, at (217) 493-9959, phone; (217) 333-4949, fax; e-mail: spost@mail.inhs.uiuc.edu.; or fill out the form on the back page of this newsletter. Also contact the registrar with suggestions for courses you would like to see offered.

Join us and learn about "The Nature of Illinois."

Michael Jeffords, Office of the Chief

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ILLINOIS
NATURAL
HISTORY
SURVEY
607 East Peabody Drive,
Champaign, Illinois
61820 USA

IWIN

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Course Topics

(Check with registrar for current course offerings)

- Biology of Lake Michigan/Great Lakes
- Biodiversity: What Is It and Why Is It Important?
- Habitat Fragmentation in the Illinois Landscape
- The Natural Divisions of Illinois: What Are They?
- Birds, Beasts, and Bugs: How to Identifiy the Denizens of Field, Forest, and Stream
- The Aesthetic Landscape: Forest, Field, and Stream
- The Life and Lore of Medicinal Plants
- Field Entomology: The Insects of Illinois
- The Ecology of Birds
- Wildflowers of Illinois
- Natural History of Southern Illinois
- Natural History Photography

If you are interested in being on the IWIN mailing list for courses offered, please fill out and return this card to Illinois Natural History Survey, Attn. Susan Post, Registrar, 607 East Peabody Drive, Champaign, IL 61820

Name_____

Address_____

_____

_____

Phone and/or Fax _____

E-mail _____

Please keep me notified of all IWIN course offerings

Course participants learning natural history photography. **Photo by Michael Jeffords, INHS Office of the Chief**

by the Illinois Natural History Survey, 607 East Peabody Drive, campus of the division of the Illinois Resources

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INSIDE

The Eastern Massasauga at Carlyle Lake

Few other animal groups are as persecuted as rattlesnakes. From old western movies where six-foot-long rattlers rear up to strike a cowboy on horseback to outrageous folktales of rattlesnakes chasing humans, a lot of bad press has been directed at rattlesnakes. In reality most rattlesnakes present very little threat to humans. They are much more likely to lay quietly and let you pass than they are to rattle or even flick their tongues. One species in particular is undeserving of the reputation as an aggressive killer. This is the massasauga or swamp rattlesnake, *Sistrurus catenatus*, one of two species of rattlesnakes found in Illinois (the other is the timber rattlesnake, *Crotalus horridus*). At less than two feet in length, the massasauga is one of the smallest rattlesnake species. It is also very secretive and not prone to bite even when disturbed.

Eastern massasauga (*Sistrurus catenatus*).
Photo by Christopher Phillips, INHS Center for Biodiversity

At the time of European settlement, the massasauga was found throughout the northern two-thirds of Illinois. There are accounts of early travelers and farmers encountering 20 or more massasaugas in a single spring day. Within a very few years, however, habitat destruction and outright persecution reduced the Illinois range of the massasauga to a few widely scattered populations. As early as 1890 it was noted that the massasauga was in decline. Today there are only three or four populations remaining in Illinois. Only the population at Carlyle Lake in Clinton County is thought to be large enough to have any hope of surviving the next 20 years.

It is not clear when the Carlyle Lake population first became known to Illinois biologists. The first reference to massasaugas at Carlyle Lake that I am aware of is from Mike Morris, a herpetologist who compiled range maps for all Illinois amphibians and reptiles. His massasauga map from the early 1980s shows a dot in Clinton County at about the location of Carlyle Lake. However, it was not until 1991 that any attempt to keep records on the Carlyle massasaugas was initiated. It was then that Scott Ballard, District Heritage Biologist with the Illinois Department of Natural Resources (IDNR), began keeping track of when and where massasaugas were encountered at the lake. Scott's work showed that between 1991 and 1998 from 2 to 20 massasaugas were incidentally encountered each year. Unfortunately, Scott also discovered that some of these encounters were the result of snakes being hit by lawn mowers or automobiles and others were snakes killed by uninformed park visitors or landown-

Continued on back page

New Predators and Parasites of Earthworms in Illinois

Earthworms are important members of the soil community, comprising 20% or more of its living biomass. By fragmenting plant residues and incorporating them into the soil, earthworms act as regulators of decomposition and nutrient cycling. Their burrowing and casting activities affect many physical characteristics of the soil, including macroporosity, aggregate size and stability, water infiltration and drainage, and soil aeration. Earthworms are a part of the diet of hundreds of vertebrate and invertebrate animals, and can also serve as hosts for a variety of parasitic and disease organisms. The influences of predators, pathogens, and parasites on the dynamics of earthworm populations have proven difficult to determine. They have cryptic habits that make them difficult to observe undisturbed, it is difficult to accurately estimate their abundance, and they leave behind little trace when they die.

***Phasmarhabditis* sp.: a parasitic nematode isolated from nightcrawlers**

A variety of parasites and pathogens have been shown to infect earthworms. These include bacteria, fungi, protozoa, rotifers, platyhelminths, mites, parasitic fly larvae, and nematodes. Of the nine families of nematodes that have been recorded from lumbricid earthworms, most use earthworms as intermediate hosts and are mostly innocuous to the worms. During 1997 in Champaign, Illinois, we collected a nightcrawler (*Lumbricus terrestris)* suffering from a nematode infection that has never before been described. Within days of isolating this earthworm, it died and thousands of nematodes emerged from its body (Fig. 1). Subsequently, earthworms infected with the same nematode have been found on two more occasions, most recently in April 1999. In all cases, infected worms died shortly after isolation, and were quickly covered with thousands of nematodes.

In the laboratory, we have been able to culture this nematode by exposing it to healthy earthworms or by growing it on an artificial diet. The nematode forms an infective juvenile stage called a dauer that locates and enters its host. The host appears to be overcome by a bacterial infection, and the nematodes subsequently feed on the bacteria and reproduce. *L. terrestris* is the only worm we have found infected with this nematode under natural conditions. However, in laboratory experiments nematodes have successfully infected the earthworms *Allolobophora chlorotica*, *Aporrectodea turgida*, *Ap. trapezoides*, *Eisenia fetida*, and *Octolasion tyrtaeum*.

This nematode appears to be a member of the genus *Phasmarhabditis*, which includes five described species from Europe, Asia, Africa, and Australia in marine, littoral, and terrestrial habitats. The three terrestrial species that have been described are parasitic in snails and slugs. One of these, *P. hermaphrodita*, has been developed as a biological pesticide for controlling slugs and is now commercially available in several European countries. Our isolate is morphologically indistinguishable from *P. neopapillosa*, another slug parasite. Unfortunately, the group has not been well studied and it is not certain that *P. hermaphrodita* and *P. neopapillosa* are truly two separate species.

Very little is known about the ecology of species of *Phasmarhabditis*. Because of the possibility of using these nematodes beneficially for managing pest slug populations, it is especially important to understand details about their host ranges and pathogenicity. Our work will add to this knowledge.

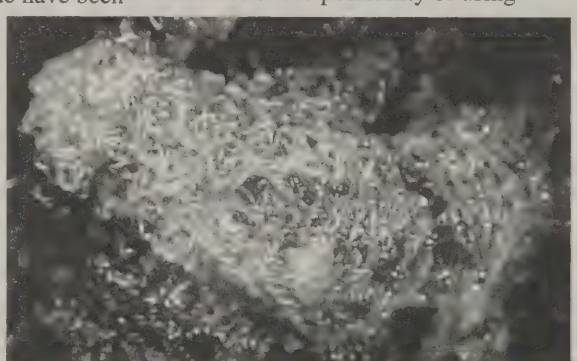


Figure 1. *Phasmarhabditis* nematodes devouring an earthworm. Photo by Ed Zaborski, INHS Center for Economic Entomology

***Bipalium adventitium*: an earthworm predator newly reported in Illinois**

Bipalium adventitium (Fig.2) is an exotic land planarian that feeds on earthworms. Thought to be a native of Southeast Asia, *B. adventitium* was first described in 1943 from specimens collected in California. It was probably introduced to North America accidentally during the 1900s in soil on the roots of horticultural plants. Since its original description from California, new reports of its discovery have been published in Connecticut, Massachusetts, Maryland, New York, Pennsylvania, Tennessee, and Washington. Recently, dozens of specimens of *B. adventitium* were collected from a residential area in Urbana, Illinois, further expanding its known distribution in North America. Because the planarians appear most commonly in urban and suburban settings, their dispersal appears to be passive, most likely in soil on horticultural plants and turf in the horticultural trade. Subsequent dispersal is active, with planarians eventually being found in some wooded and agricultural habitats.

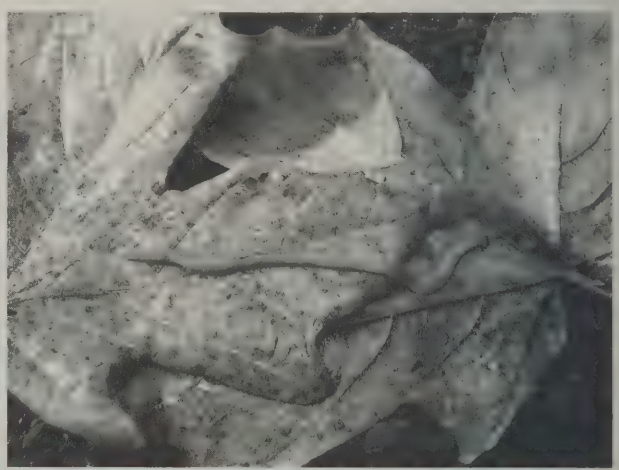
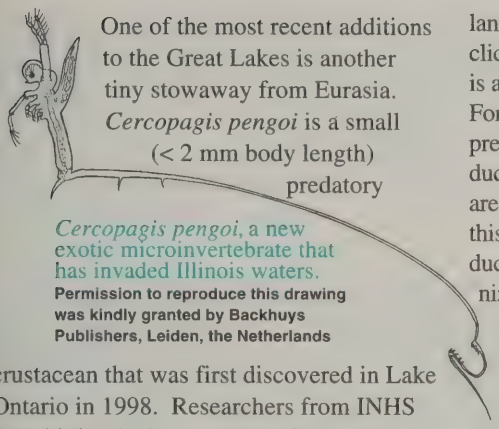


Figure 2. *Bipalium adventitium* is an exotic land planarian that feeds on earthworms. Photo by Ed Zaborski, INHS Center for Economic Entomology

Despite early suggestions that it may also prey on slugs, laboratory studies to date indicate that *B. adventitium* is prima-

Continued on next page

New Predator Invades the Great Lakes



Cercopagis pengoi, a new exotic microinvertebrate that has invaded Illinois waters.
Permission to reproduce this drawing was kindly granted by Backhuys Publishers, Leiden, the Netherlands

One of the most recent additions to the Great Lakes is another tiny stowaway from Eurasia. *Cercopagis pengoi* is a small (< 2 mm body length) predatory crustacean that was first discovered in Lake Ontario in 1998. Researchers from INHS found it in plankton samples from southwest Lake Michigan in the fall of 1999. *Cercopagis*, which has become known as the "fishhook flea," possesses a tail spine that can be up to five times as long as its body. In *Cercopagis*, the tail spine includes a predominate curve, which separates it from the closely related *Bythotrephes cederstroemi* that invaded the Great Lakes in the 1980s. Mature individuals possess three pairs of lateral barbs on the tail spine of *Cercopagis*. Because of this long, spiny, appendage, *Cercopagis* and *Bythotrephes* are often found fouling fishing lines in the Great Lakes. The clogging of reels and fouling of nets makes these exotic species potential nuisances in these systems.

Both *Cercopagis* and *Bythotrephes* possess life history traits that make them good invaders. Like many other species of zooplankton, they reproduce by means of cyclic parthenogenesis, which means there is an alternation of reproductive mode. For most of the year, only females are present in the water. These females produce eggs asexually, which in a few days are released as newborn daughters. With this mode of reproduction, a single introduced individual could potentially colonize an entire lake!

When living conditions begin to deteriorate (not enough food, too many predators), something in the environment signals the females to begin producing sons instead of daughters. Once there are both males and females in the water, a different type of egg is produced. These eggs are known as "resting eggs" or "diapausing eggs" because instead of hatching right away they are capable of remaining dormant during the time when environmental conditions are bad. Once favorable conditions return, some of these eggs hatch and start a new population.

Live animals require water to be transported from lake to lake. Therefore, the control measures used for other exotic aquatic species (emptying of bait buckets and live wells, washing and drying of all gear) will also help to reduce the spread of *Cercopagis*. The diapausing eggs are a different story. These eggs can hatch after they have dried up or frozen, even if it is several years later. Moreover, since females carrying these eggs can "stick" to fishing gear and other recreational equipment, care must be taking to thoroughly clean all equipment after leaving a lake (instead of just allowing things to dry).

It is not known what effect this new species will have on the Great Lakes ecosystem. When *Bythotrephes* invaded Lake Michigan, its entrance to the lake coincided with marked changes in the food web. Both *Bythotrephes* and *Cercopagis* are predators, eating other species of zooplankton that are also the primary food for many species of fish. The presence of another invertebrate zooplankton predator may alter the existing zooplankton assemblage, with implications for the growth and survival of important fish species like yellow perch and alewife. However, *Cercopagis* is considerably smaller than *Bythotrephes*, so it may fall victim to predation by the larger predatory species. In addition, *Cercopagis* and *Bythotrephes* may provide additional food for fish. *Bythotrephes* is commonly eaten by yellow perch and alewife, although the benefit of eating this spiny species for fish is unclear due to problems they experience digesting and passing the spiny leftovers. *Cercopagis* also was found in alewife guts last fall, but the potential impact of these and other fish on *Cercopagis* is not clear. Future research will help us understand the role of this new species in North American Lakes.

Carla Caceres, John Dettmers, and Patrice M. Charlebois, Center for Aquatic Ecology

Earthworms

continued from previous page

rily an earthworm predator. In all published studies, *B. adventitium* attacked all species of earthworms presented to it (eight species in all). In laboratory trials with *B. adventitium* from Illinois, all species of earthworms presented were attacked, including three species of earthworms not previously reported as prey. Earthworms many times the size of the planarians were attacked, and earthworms up to 10 times greater in size rarely survive attacks.

The pattern of colonization of *B. adventitium* in North America is very similar to that of an ecologically similar New Zealand land planarian, *Artioposthia triangulata*, that was accidentally introduced into Ireland in the early 1960s. Where this planarian has become established, it has been shown to reduce earthworm populations to below detectable levels, possibly to extinction. Few ecological studies of *B. adventitium* populations in North America have been conducted thus far, and it is not known what impact its establishment may have on earthworm populations or on the important soil processes that earthworms mediate, such as soil formation, organic matter transformations, and nutrient cycling.

The extent of the distribution of *B. adventitium* in Illinois is unknown. Home gardeners and nursery workers may see these animals on the soil surface under boards and stones on the soil, or crawling on the soil surface after rains. It is slow moving, up to 2.5 inches long and up to 1/8 of an inch wide when crawling. It is pale brown or tan with a thin dark brown line running down its back. Survey scientists would appreciate receiving reports of any such findings. Contact Ed Zaborski at (217) 265-0330, or zaborski@uiuc.edu by e-mail.

Ed Zaborski, Center for Economic Entomology

Smallmouth Bass and Artificial Reefs in Lake Michigan

During November 1999, an artificial reef (approximately 244 m long x 6–9 m wide x 1–3 m high) was placed into Lake Michigan just south of Chicago to improve smallmouth bass fishing in the area. INHS researchers are currently investigating the effectiveness of this artificial reef for attracting or producing fish. The difference between attracting and producing fish is a critical one, both for managing the smallmouth bass fishery and for understanding the importance of artificial structures to regional population dynamics. For instance, if the artificial reef attracts but does not produce additional smallmouth bass, it may serve as a population sink if anglers harvest more smallmouth bass from the artificial reef than they would otherwise. Conversely, if the artificial reef produces additional smallmouth bass, that added production can offset angler harvest and may provide a more stable population of smallmouth bass than if the artificial reef merely attracted fish.
To address this question, Survey researchers are sampling both the artificial reef site and a nearby reference site to explore possible differences at these two sites before and after artificial reef construction. Researchers want to determine if the artificial reef (1) establishes a more productive food web than representative nonreef habitat, (2) increases spawning by fishes that are strongly associated with the reef, (3) provides habitat for adult sport fishes to use for feeding, resting, and spawning, (4) increases production of local sport fishes, and (5) produces a positive change in angler use and catch rates.

We studied the biotic and abiotic conditions of the artificial reef and reference sites during May-September 1999 to establish baseline data before reef construction. Both sites are located approximately 0.8 km offshore at a depth of 7.5 m and are separated from north to south by 1 km. We sampled several life stages of fish (newly hatched larvae, juveniles, and adults), zooplankton and aquatic invertebrates (both important food items for fish), and water temperatures at each site.

Preliminary data analysis from 1999 sampling indicates that the artificial reef and reference sites were comparable in abiotic and biotic characteristics before the reef was constructed. Water temperatures were similar throughout the spring and summer, with temperatures peaking around 25°C in late July. SCUBA surveys determined that the substrate at each site was a mix of sand, silt, and clay with outcroppings of hard substrate that support zebra mussels.

Artificial reef under construction in Lake Michigan with Chicago in background. **Photo courtesy of Illinois Department of Natural Resources**

Zooplankton density was similar between sites; zooplankton consisted primarily of calanoid and cyclopoid copepods, and rotifers, all important prey for fish. In addition, planktonic zebra mussel larvae, called veligers, were quite abundant in zooplankton samples from both areas.

Fish sampling at the artificial reef and reference sites identified similar larval and adult fish densities and composition before reef placement. Larval fish catches were characterized by a high percentage of alewife; yellow perch and Centrarchidae spp. appeared in lower percentages. Visual surveys of adult fish identified that the round goby, an exotic species, dominated the benthic fish assemblage at the artificial reef and reference sites, except for one date when 12 adult smallmouth bass were observed roving in the area. Generally, only adult round gobies were observed; however, in late August young-of-year round gobies were observed, indicating that round gobies are successfully spawning at both sites.

The 1999 observations suggest that zebra mussels and round gobies will be important components of the community associated with the artificial reef. Round gobies are abundant in the region and are currently limited to available structures (i.e., intermittent rocks and bedrock outcroppings); thus, the addition of a large amount of artificial structure will substantially increase suitable habitat, likely increasing carrying capacity for the round goby. Researchers also expect the zebra mussel to be an early colonizer because of the hard structure provided by the reef and the presence of veligers in the water column at the reef site.

Smallmouth bass will likely use the artificial reef, although the extent and intensity of that use is still unclear. Studies in Lake Erie have documented that smallmouth bass are attracted to similar artificial structures but no quantitative measure of their use of these structures has been completed. Therefore, the observation of smallmouth bass and round gobies indicates that the artificial reef may provide suitable habitat and prey for attracting smallmouth bass to the area. However, it will remain unclear if the reef attracts or produces smallmouth until additional comparisons are made after reef construction.

Data collection will continue at the artificial reef and reference sites during 2000 and 2001. In addition, anglers will be interviewed to determine if increased catch rates of smallmouth bass result from the addition of the reef. These data will provide an understanding of the role artificial reefs play in Lake Michigan and identify the effectiveness of this artificial reef for attracting or producing smallmouth bass.

Matthew J. Raffenberg and John M. Dettmers, Center for Aquatic Ecology

Filling the GAP to Map Biodiversity in Illinois

The main agenda of the Illinois Gap Analysis Project (IL-GAP), part of a nationwide project funded by the U.S. Geographical Survey, is to locate unprotected land that has or is predicted to have high biodiversity. Vertebrate species and vegetation are mapped as part of this process.

The Illinois Natural History Survey (INHS) is using Landsat Thematic Mapper (TM) satellite imagery as the primary means of mapping the state's vegetation. By combining satellite imagery data analysis with other forms of ancillary data, the INHS is able to classify the vegetation to the alliance, or species association, level in most cases. In some areas vegetation is extremely mixed, in which case the vegetation is mapped at more of a natural community level.

Satellite imagery is collected from two dates, spring and fall, to account for seasonal variations such as agriculture, tree leaf-on and leaf-off, wetness, and so forth. Landsat TM imagery has a resolution of 30 meters by 30 meters. Digital elevation models (DEMs), also with 30-meter resolution, are used to create a slope/aspect index (SAI) to represent topological differences across the landscape. The imagery is combined with the SAI and statistically analyzed for clusters of similarity, accounting for spectral and topological variables. These clusters of similarity are then classified using ancillary data and expert knowledge.

Ancillary data is found in many forms and may vary across different regions of the state. Some common types of ancillary data include black-and-white aerial photography, color infrared aerial photography, updated wetlands inventories, county soil surveys, local vegetation maps, U.S. Forest Service Forest Inventory Analysis (FIA) points, Illinois Natural Areas Inventory, and hydrography.

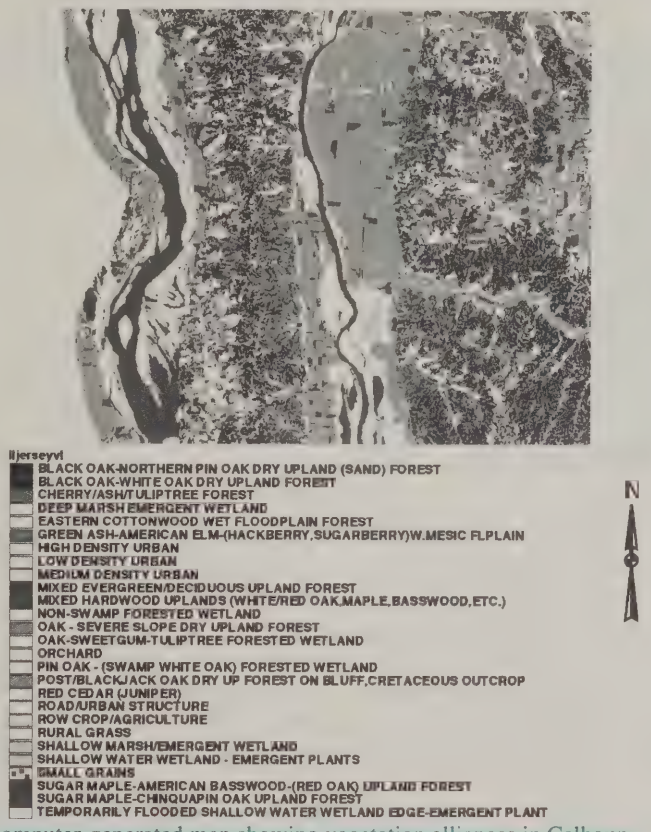
One of the major challenges of classifying the vegetation of Illinois is that the landscape has been disturbed many times over the past 150 years. The result is fragmented forests with mixed and invasive vegetation and few natural-state communities. Even vegetation distribution reports from the 1960s are dated in some areas as invasive, successional, and opportunistic species have moved into areas previously thought to be unsuitable. This makes it difficult to follow TNC vegetation alliance naming schemes in their pure forms. As a result, the IL-GAP project will rely heavily on the observations and knowledge of district foresters and forest preserve professionals to accurately classify the vegetation on the Illinois landscape as it is seen today.

When a "rough" classification of a satellite scene is finished, maps are sent to the district forester offices of the Illinois Department of Natural Resources where they will be checked for content and general correctness. This will allow for minor changes to be made, such as breaking out more classes, combining classes, or even renaming classes to better reflect the actual composition. Once the classification for the entire state is completed, an official accuracy assessment will be performed on each class that has been mapped. The goal of this project is to reach 80% accuracy for each class.

The final analysis and end products of the IL-GAP project will inevitably allow us to map and locate areas where habitat conservation and management is needed most in order to maintain high biodiversity for all species of flora and fauna.

Linda Schwab, Center for Wildlife Ecology

IL-GAP Vegetation Alliances
Calhoun County



Computer-generated map showing vegetation alliances in Calhoun County based on data used by GAP staff at INHS. Map created by Linda Schwab, INHS Center for Wildlife Ecology

The vegetation alliances used to name the classes are taken from *An Alliance Level Classification of the Vegetation of the Midwestern United States*, (Drake and Faber-Langendoen, The Nature Conservancy (TNC), 1997), following the National Gap Analysis protocol. The TNC document lists detailed descriptions of vegetation alliances, their natural community type, and similar Society of American Foresters (SAF) forest types, where applicable.

Species Spotlight

American Robin

Susan Post

Robin is one of the most native and democratic of our birds; he is one of the family, and seems much nearer to us than those rare, exotic, visitants . . . Hardy, noisy, frolicsome, neighborly and domestic in his habits, strong of wings, and bold in spirit, he is the pioneer of the thrush family, and well worthy of the finer artists whose coming he heralds and in a measure prepares us for.
—John Burroughs 1913

American Robin (*Turdus migratorius*), a favorite "harbinger of spring."
Photo by Michael Jeffords, INHS Center for Economic Entomology

The American Robin, *Turdus migratorius*, is one of the first birds children learn to identify. Robins reside on our lawns, in our gardens, fields, and pastures, and they literally "set the standard" for all other songbirds. Many nature lovers judge the size of all other birds by whether they are the same size, larger, or smaller than the American Robin. They even possess their own colors: eggs are robin's-egg blue and their breast is robin-red. A light spring snow coming after the bird returns is referred to as a "robin snow."

The American Robin is the largest of the North American thrushes with a length of 9–11 inches. It has a reddish breast, incomplete white eye rings, white corners on its tail, and a dark head. The female's head is gray while the male's is black. Robins go through one complete molt each year between late July and early October.

Robins are one of the few native species to have benefited from human development. Prior to European settlement, they were found only in open areas within forests and woods. In 1932 Frank Farley wrote, "When the hard prairie lands were broken up, it was noted that earthworms were absent, but with the arrival of settlers, it was not long before the worms began to appear. . . ." By the 1930s, Robins had become North America's most widespread bird, and today they are one of the most widespread birds of the western hemisphere and one of the most adaptable, occurring from the Arctic to the tropics. Temperature is a key factor in their existence—they need thawed ground so they can dig earthworms.

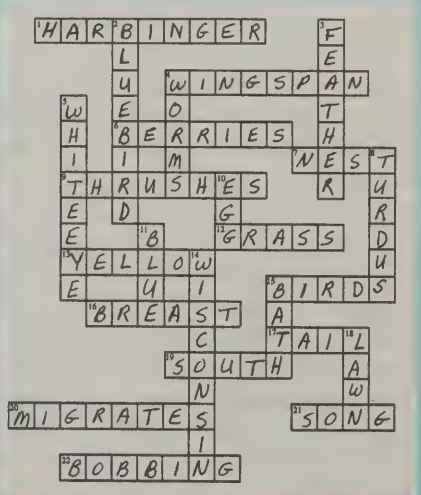
In the spring and summer Robins feed primarily on the ground, searching for earthworms, beetles, and caterpillars. In fall and winter their diet is primarily berries. The classic Robin-hunting behavior is to run or hop briskly across a lawn, stop, cock its head sideways, and then quickly grab a wiggling worm. A Robin's eyes are only slightly movable, so it must tilt its head to focus on objects. Head-tilting offers the greatest visual sharpness, and while it appears the Robin is listening, it is actually carefully looking.

Robins tend to return to nest in the area where they were raised, and may return year after year to the same tree or yard. Their selection of nest sites is flexible and includes low bushes, window sills, or even porch lights. Preferred sites are older trees with large horizontal limbs. Nest building materials are anything the bird might come upon; the only real requirement is a good source of mud to hold everything together. Nesting can even be delayed due to lack of mud. Once the nest is built, egg-laying begins. With one egg laid per day, a nest will usually contain four pastel blue eggs. Incubation lasts 11 to 14 days. Once hatched from the egg, the pink chicks are helpless, but rapidly grow their first gray feathers. They will leave the nest before they can fly, moving onto the nearby branches, often ending up hopping about on the ground. While these bobtail babies appear to be helpless, remember to leave them where they are, their parents will take care of them.

Teachers Guide to Robin Crossword

All of the clues refer to the American Robin. Some may be answered by reading the "Species Spotlight" in this *Survey Reports*. For other answers, the students may need to refer to a field guide to North American birds, or a book on bird behavior.

See answers provided at right.



Robin Crossword

Carolyn Nixon

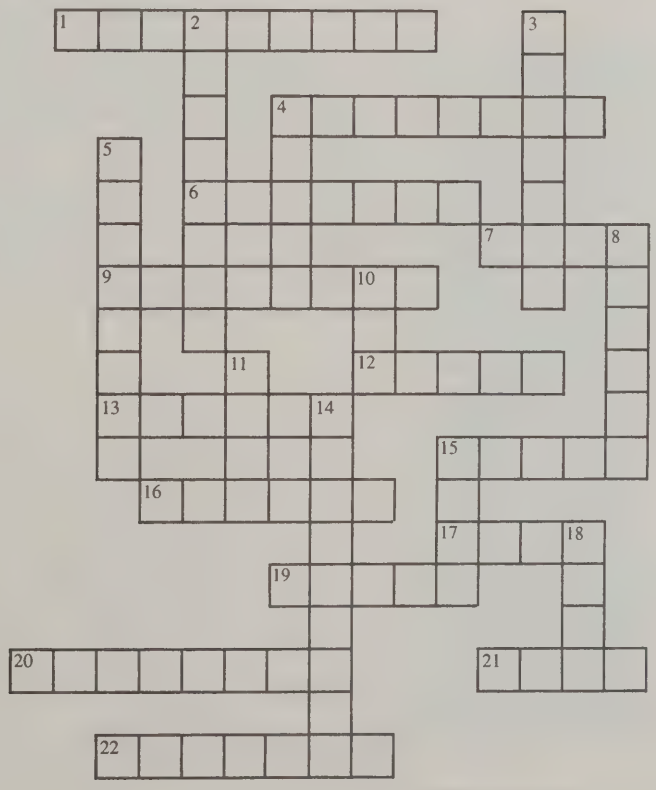
Robin Crossword Puzzle

Across

1. A Robin is often called a "_____ of spring."
4. The distance between the wingtips of a Robin is known as_____.
6. During fall and winter, a Robin eats a lot of these.
7. Before it can fly, a baby robin lives here.
9. Robins are in a group of birds known as _____.
12. A Robin builds its nest mostly of mud and this.
13. The color of a Robin's bill.
15. Robins are a member of a group of animals known as _____.
16. This part of the Robin is brick red.
17. In Illinois, this part of the Robin usually has white tips.
19. In the fall, Robins tend to fly in this general direction.
20. A Robin usually does this when the weather changes in spring or fall.
21. A Robin uses this to tell other Robins that this is his territory.
22. According to a song, a Robin does this as he moves along.

Down

2. A cousin of the Robin, who prefers to live in hollow trees or wooden boxes.
3. A specialized scale that helps keep Robins warm.
4. An early Robin gets more of these.
5. The face of a Robin has a _____ ring. (two words)
8. Robins are in this genus.
10. A baby Robin hatches out of one of these.
11. The color of 10 down.
14. This Illinois neighbor that has the Robin as its state bird.
15. A good way to give a Robin water is to put it in a bird-_____.
18. On the _____ is a good place to look for Robins.



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Massasaugas

continued from front page

ers. In 1994, the massasauga was listed as endangered in Illinois and this resulted in increased interest in the welfare of the species. More recently, plans for commercial development at Carlyle have been presented by various government agencies and private groups. These development plans have caused the IDNR to step up its investigations into the status of the massasauga at Carlyle.

In response to this need, I started studying the massasauga at Carlyle Lake in the fall of 1998. The initial purpose of my study was to conduct a systematic survey for massasaugas at South Shore State Park, one of the two IDNR-owned or managed properties at the lake. In Illinois, massasaugas spend the winter hibernating underground in crayfish burrows, so I started my survey by looking for appropriate crayfish habitat. At Carlyle this is grassland where the water table is seasonally elevated. I identified a potential site and returned the following spring to start my research. I was lucky enough to have chosen an area that is used by a large number of massasaugas. I documented the timing of emergence and dispersal from the hibernation sites, and established baseline population data. My initial results indicate that massasaugas emerge from hibernation in crayfish burrows (a process called egress) in late March and remain in the general vicinity for up to 36 days. After that, they move out into their summer ranges to forage for food and locate mates. An in-depth analysis of the specific locations where massasaugas were found suggests that during egress massasaugas select locations closer to retreats (crayfish holes or logs) and shrubs compared to random locations. This proximity to cover may allow massasaugas to escape predation, especially from aerial predators, such as hawks.

In the next phase of my research at Carlyle I will attempt to locate as many hibernation sites as possible and further investigate timing of egress and population size. I will also radio-track 10 or more snakes to find out where they go when they leave the hibernation sites. The final product of these efforts will be a better picture of how many massasaugas live at Carlyle and how they utilize the various habitat types at the lake. This information will be used to direct commercial development away from the areas that are used by massasaugas. Hopefully, it will also be part of a larger management plan that includes purchase of additional habitat and educational programs that counter the "bad press" already in existence. Only through such a comprehensive plan does the massasauga have any real chance of continued existence at Carlyle Lake or in Illinois.

Christopher Phillips, Center for Biodiversity

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ILLINOIS NATURAL HISTORY SURVEY

Reports

Summer 2000
No. 364

INSIDE

New INHS Building Planned

After several years of planning, the Survey may soon begin construction on a new building with the working title of Natural History Research Center. A site has been selected, architects are working on the design, and partial funding is in hand. While much remains to be done, we hope that bids can be taken on Phase I before this time next year. This new Natural History Research Center will provide offices, laboratories, and specialized facilities for up to 400 people (250 scientists, plus 150 support staff and students). Total building size is projected at about 210,000 gross square feet and 125,105 net square feet.

For the last 60 years, the Illinois Natural History Survey and the State Geological Survey have jointly occupied the Natural Resources Building on Peabody Drive in Champaign. Inadequate space has been a critical problem for many years. In October 1988 a study by the University of Illinois identified a combined space shortage of over 100,000 net square feet for the two Surveys. By August 1997 the shortage had increased to nearly 150,000 net square feet. In addition, the Surveys lack certain specialized facilities necessary for modern discovery research. When this building is completed and the Natural History Survey moves from the Natural Resources Building, the State Geological Survey will expand into the vacated space. By these two moves, the immediate and critical space needs of both Surveys will be addressed.

Architectural rendering of the Natural History Research Center. **Drawing courtesy of Teng and Associates Inc., Chicago**

The new facility will be located on the University of Illinois Urbana campus, just south of Gregory Drive and facing Dorner Drive immediately north of the Plant Sciences Laboratory. This location is within easy walking distance of all of our primary collaborators in both the College of Agricultural, Consumer and Environmental Sciences and the College of Liberal Arts and Sciences.

Continued on back page

Exotic Shrubs and Songbird Nest Success

Invasion of exotic or non-native species is now clearly acknowledged to be a problem of global significance, and an effective means for reducing or eliminating future invasion has recently become a federally mandated priority. Amid the growing interest in the effects of exotic species on native species and the newly acquired roles of exotic species within ecosystems, there is growing concern that exotics, and all their problems, are here to stay.

While conducting a study aimed at testing a variety of theoretical ideas about the potential impact of predators on songbird reproductive ecology, my students and I collected a large data set on the use of plant species as substrates for songbird nests. In the forest where this work was conducted at The Morton Arboretum in DuPage County, exotic shrubs, in particular Asian bush honeysuckle (*Lonicera maackii*) and common buckthorn (*Rhamnus cathartica*), dominate large sections of the understory. In some sections there may be no other woody understory species present besides these two exotics. Early on in this investigation, it became clear that a majority of nests of all bird species were located in these two exotic plant species. Because exotic species like honeysuckle and buckthorn are often the targets of eradication, this led to concern about unintended effects such management may also have on the native bird species nesting in them. Does this situation pose a paradox for land managers? Or can buckthorn and honeysuckle eradication proceed in a way that minimizes negative effects on native bird species that use these shrubs for nesting sites?

To better understand the effect of substrate use for nesting location, we analyzed our data to address the question, "Does the plant species used for nest site location correlate with nest success or failure?" We restricted our analysis to two bird species, American Robin (*Turdus migratorius*) and Wood Thrush (*Hylocichla mustelina*), for which our data were most complete. From these data sets, we selected nests for which we had complete data (from date found to conclusion of the nest attempt) with unambiguous fates (success or failure). For some nests that failed due to predation, we could identify the predator. In addition, we knew from other data that the principal mammalian nest predator in our study system was the raccoon (*Procyon lotor*), and the principal avian predator was the Blue Jay (*Cyanocitta cristata*).

Raccoon caught in the act of raiding a bird nest. **Photo by Chris Whelan, INHS Center for Biodiversity**

This analysis was revealing. American Robin nests placed in the exotic honeysuckle and buckthorn suffered significantly higher rates of predation than nests placed in comparable positions in native trees. Although currently untested, we believe the reasons for this increased nest predation in exotics may be related to a drop in average nest heights in exotics, their lack of formidable thorns that might increase foraging costs of mammalian predators, and their thick, sturdy branches, which may facilitate accessibility for large mammals like raccoons.

For Wood Thrushes, the picture is more complicated. Over the course of the study, American Robins built progressively more and more nests in exotic substrates, a choice of nest location that increased their vertical overlap with Wood Thrushes. As this vertical overlap increased, predation on Wood Thrush nests likewise increased. Results from a further experiment indicated that alternative nesting strategies could be linked in a negative interaction chain via a common, shared predator. The result of our experiment also suggested that the same phenomenon may have been the mechanism linking increased overlap of Robin and Thrush nests with greater predation on the Thrush nests. In our study system, the data indicate that the shared predator is the raccoon.

Our results demonstrated a direct negative effect of nesting in exotic plant species on American Robins, but an indirect negative effect (via Robins and a shared predator) on Wood Thrushes. The work further begs the question, "Do these results also pertain elsewhere in the now extensive ranges of honeysuckle and buckthorn in North America?" We do know that honeysuckle is commonly used for nesting in New Hampshire and New York state, suggesting that this species may be contributing to nest failure over a wide geographic region. Our results indicate that much more work needs to be done to understand the structure-function relationships by which plant species used as nesting substrate affect the fate of those nests. More immediately, the results indicate one more reason why prevention of invasion by exotic species is a conservation priority. And finally, they suggest that replacement of exotic shrubs with the native species they apparently displaced will improve not only the biodiversity of the native plant community, but also the ecological conditions for animal species using them.

Christopher J. Whelan, Center for Biodiversity

Illinois Pilot Watershed Program

Agricultural practices contribute to water pollution by adding nutrients (fertilizers), sediments, and pesticides to the stream through surface runoff. Best Management Practices (BMPs) are strategies designed to improve the quality of a stream by reducing pollution from agricultural areas. These practices range from on-field (planting trees and grasses adjacent to the stream) to in-stream (bank stabilization) approaches. Studies investigating the impact of management practices on improved water quality have concentrated on in-stream strategies and have focused traditionally on physical/chemical characteristics such as nutrient concentrations or sediment yield at a particular location in a stream over a short period of time. Little is known about the responses of aquatic insects, crayfish, and fish to the implementation of BMPs across the entire area that drains into the stream (watershed-wide implementation of BMPs).

The Illinois Pilot Watershed Program is designed to address watershed issues such as erosion, flooding, and deposition of nutrients/sediment in streams and to examine the effects of management practices on improving the entire watershed. As an initial pilot study, four watersheds across the state were selected in areas with several watershed issues or problems and where local interest existed (Fig. 1). Due to the extensive nature of the program, a number of state and federal agencies along with citizen-based groups are participating in the ecological, economic, and social aspects of this program. In each pilot watershed, planning committees and coordinators, which are made up of local watershed interest groups along with local agency personnel from the Natural Resources Conservation Service and the Soil and Water Conservation Districts, identify concerns and evaluate conservation needs in their respective watersheds. These committees also conduct visits with participating landowners to discuss suitability of BMPs and hold local meetings to address landowner questions.

Funding for installation of BMPs is provided by the Illinois Department of Natural Resources through citizen partnerships with landowners. Additional funding for conservation practices and watershed planning as well as technical assistance in implementing BMPs is also provided by the Illinois Environmental Protection Agency, the Illinois Department of Agriculture, and the Farm Service Agency.

Assessment of watershed management practices is carried out primarily by the Illinois Natural History Survey (INHS), the Illinois State Water Survey (ISWS), and the Geographic Modeling Systems Laboratory (GMSL) at the University of Illinois. Effects of BMPs on physical stream habitat and aquatic organisms are being evaluated by the INHS, while the ISWS is carrying out the water-quality analysis. GMSL is using stream flow and erosion data to evaluate potential influences of BMPs at reducing pollution and erosion and to assess locations in the watershed where BMPs will be most effective.

The focus of INHS' first year of data collection in 1998 was to determine the similarity of the pilot sampling sites with their corresponding reference or "control" sites. Our aquatic assessment focuses on in-stream habitat, aquatic insects, and fish. Habitat measurements include stream width, depth, flow, and substrate as well as vegetation on stream banks and adjacent land. Aquatic insects are collected from riffles (shallow areas with turbulent flow), runs (moderately deep areas with moderate stream flow), and pools (deep sandy areas with slow flow) based on the proportion of these habitat types within each site. Fish are sampled using an AC electric seine which puts an electric current into the water and stuns the fish. Biologists collect, identify, measure, and weigh the stunned fish. From our 1998 fish data, we found that pilot and reference watersheds were similar in number and types of fish species caught. This suggests that, in general, our pairings are well matched for examining differences in fish composition after BMPs are installed. As BMPs are implemented in the pilot watersheds, we anticipate differences between pilot and reference streams to increase as a result of improved habitat and water quality in the pilots watersheds.

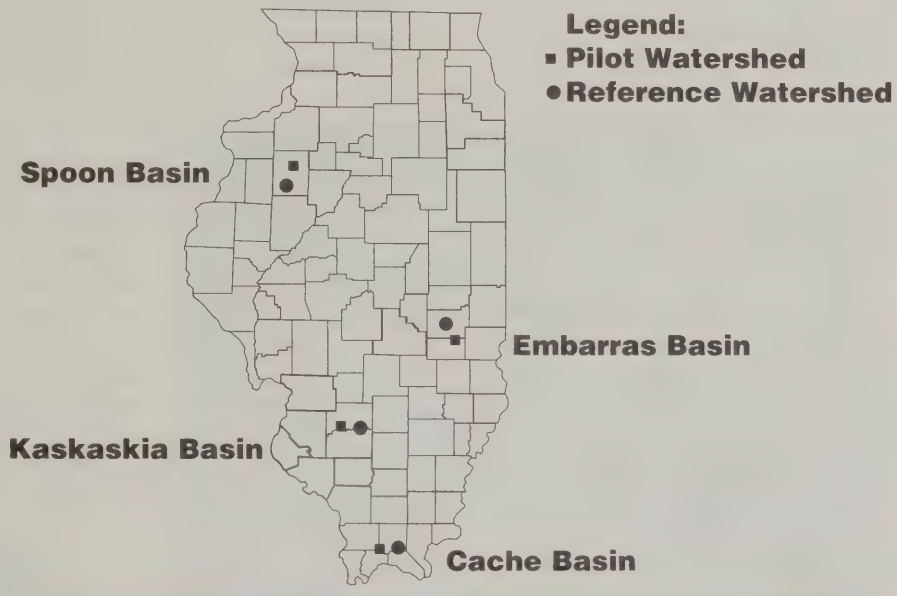


Figure 1. Location of the four river basins with their corresponding pilot and reference sites.

Hope R. Dodd, Center for Aquatic Ecology

An Outpost on the Way to a Solution: Rotation-Resistant Western Corn Rootworms and the C-FAR Sentinel Grants Program

Natural selection plays the central role in shaping the biological world, yet its glacial pace makes the evolutionary change occurring around us appear all but invisible. Occasionally, exceptional circumstances permit us to witness the process of natural selection. Such circumstances exist today in an expanding area of Illinois, Indiana, Ohio, and Michigan: the behavior of the western corn rootworm (*Diabrotica virgifera virgifera*), an important pest of corn, has been shifting since the mid-1980s under intensive selection by annual crop rotation, allowing it to circumvent our single most cost-effective and environmentally benign management tool. The failure of crop rotation presents us with an exceptional opportunity to study evolution in our midst while working toward a solution to one of the most vexing agricultural problems of our time.

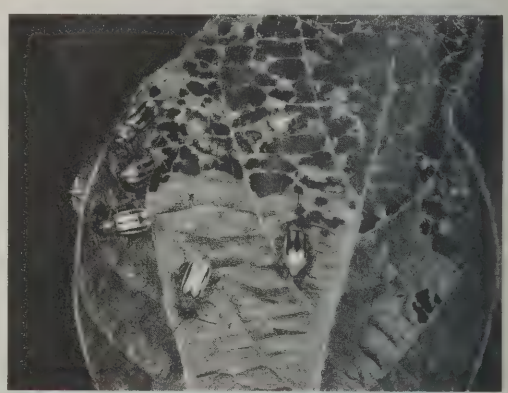
Male western corn rootworm on soybean leaf. **Photo by Joe Spencer, INHS Center for Economic Entomology**

Rotation resistance involves frequent beetle flight between corn and crops rotated with corn to lay eggs and feed in both areas. Beetles that once laid all of their eggs in cornfields are now laying many of their eggs in soybeans and other crops. By hedging their egg-laying bets and depositing eggs in many places, female beetles assure that some of their eggs will hatch in cornfields the following spring where their larvae will find the corn roots they need to survive.

For most insect problems, our first response has been to use insecticides as "fire-fighting tools" in an attempt to quench a pest outbreak before it has a chance to rage out of control. For many insects, we possess a number of effective options and at worst suffer only spotty "scorchings" in the process of gaining control. Crop rotation-resistant western corn rootworms are different. In essence we have learned that widespread use of our best western corn rootworm fire-fighting tool, annual crop rotation, sparked a behavioral resistance to rotation that is spreading like a prairie fire across the Corn Belt, the flames of which we are ill-equipped to fight. Many of the insecticides that serve as our second line of defense against the western corn rootworm are in jeopardy of losing their registrations with the EPA. Without crop rotation or soil insecticides and with transgenic corn for rootworms not yet a commercial reality, growers have few options for extinguishing a rotation-resistant western corn rootworm problem. The potential added cost to Illinois growers (more than $100 million annually) of the rotation-resistant western corn rootworm is substantial, and the potential economic and environmental impact of crop rotation's collapse across all the Corn Belt states would be staggering.

Beginning this summer, western corn rootworm research at the Illinois Natural History Survey and the University of Illinois will make a quantum leap in its scope. Mindful of the threat to corn production and the urgency of mounting a multipronged attack on this problem, the Illinois Council on Food and Agricultural Research (C-FAR) recently awarded the University of Illinois/Illinois Natural History Survey western corn rootworm research team a three-year $1,083,900 grant to study the western corn rootworm through its inaugural C-FAR Sentinel Grants Program.

The purpose of the project ("Crop Rotation Collapses as a Pest Management Tool for Western Corn Rootworms: In Search of a Solution") is to broaden the study of this problem well beyond the "fire-fighting" stage. Though rotation resistance is fundamentally a problem of movement (i.e., beetles now leave corn to lay their eggs), to understand it we must study factors that influence movement across the biological spectrum, from gene expression to agroecology. Our goals include development of a mechanistic understanding of rootworm movement and rotation resistance, improvement of grower management options, prediction of the continuing expansion of the affected area, and identification of a



Western corn rootworms decimating soybean leaf. **Photo by Joe Spencer, INHS Center for Economic Entomology**

Continued on next page

New Newsletter Publication Schedule

As of this issue of *Illinois Natural History Survey Reports*, our organization is beginning a new annual schedule of publication dates. We now will print the newsletter at quarterly rather than bimonthly intervals, which means that we will print four issues per year instead of six issues.

All of the publications produced by the Illinois Natural History Survey (INHS) are mandated by state law to be printed on recycled and recyclable paper with soy-based ink. This law is designed to reduce the negative impact on the environment as the state generates hundreds of millions of printed pages every year. As a unique and prominent steward of Illinois ecosystems, INHS is more than happy to carry out this environmentally friendly law. In addition to using recycled paper and soy ink, we are also taking advantage of the Internet's World Wide Web to create paperless, electronic pages which not only help save our natural environment but also reduce the time and expenses needed to disseminate important scientific information throughout the state and world. Therefore, every issue of this newsletter since 1995 has been placed on our Web site in addition to Annual Reports, the INHS Publications Catalog, two of our popular field guides, and images and descriptions of garden and yard insect pests.

We constantly look for new ways to publish by analyzing existing production routines to see if there are more efficient, more environmentally friendly, and less expensive alternatives to current practices. One such analysis was made for this newsletter. Interestingly, the analysis showed that annual production, handling, and distribution costs for *INHS Reports* have climbed to about $15,000 for six eight-page issues. Our initial thought was to cease creating paper copies altogether and just place the newsletter on the Web and thereby save taxpayers more than $10,000 in one stroke. However, after a little reflection, we realized that many of our subscribers may not have easy access to Web technology, so we decided to combine the printing and electronic approaches.

First, we will continue printing the newsletter but reduce the number of issues from six a year to four. Each of our issues will occur in one of the four seasons throughout the year beginning with this Summer 2000 issue. The new publication schedule is:

Summer — July 1

Fall — October 1

Winter — January 1

Spring — April 1

Second, we will continue placing each issue on the Web at URL: <http://www.inhs.uiuc.edu/chf/pub/pub_body.html#Survey_Reports>.

We encourage subscribers who have Web access to use it to read our newsletter and to contact us to remove them from our mailing list of the printed version. Readers who currently receive the printed version, but who subsequently acquire Web access, are also encouraged to remove themselves from the printed version mailing list by contacting: Charlie Warwick, INHS, 607 E. Peabody Dr., Champaign, IL 61820, Ph (217) 244-2115, e-mail: cwarwick@mail.inhs.uiuc.edu.

We hope that with your assistance we will eventually reduce our mailing list (and corresponding production costs) to a minimum, if not entirely eliminate paper production of this newsletter. Please feel free to contact us at the address above if you have questions, concerns, or comments. We welcome your ideas on how to best continue fulfilling our mission to inform citizens of scientific developments in the natural history of Illinois in the most cost-effective but accessible ways.

Charlie Warwick, INHS Publications Coordinator

Rootworms

continued from previous page

genetic signature for the adaptation. The new support will expand our capacity to investigate the biology and ecology of the western corn rootworm while applying the latest molecular techniques to seek a genetic understanding of rotation resistance.

The project involves scientists from the Illinois Natural History Survey (Joseph Spencer and Eli Levine); the University of Illinois Departments of Crop Sciences (Mike Gray and Sue Ratcliffe), Geography (Scott Isard), Natural Resources and Environmental Sciences (David Onstad), Entomology (Hugh Robertson), and Texas A&M University (Paul Mitchell); along with researchers at the Keck Center for Comparative and Functional Genomics (Harris Lewin, Mark Band, Jose Pardinas, and Lei Liu). The research team combines diverse expertise, years of experience, and a wealth of scientific resources needed to address rotation-resistance at multiple levels of analysis.

C-FAR supports research in Illinois that 1) expands markets and profitability for our agricultural products, 2) discovers and develops alternative products, practices, and enterprises that enhance healthy urban and rural communities, 3) increases our capacity to address the world's changing food and agricultural demands, 4) improves food quality and safety, and 5) facilitates sustainable use of our natural resources. Sentinel Grant Program funding is intended for projects with a broad scope and interdisciplinary flavor, needing substantial support to address a problem of significance to Illinois. Our goal is restoration of crop rotation to its former utility as a cultural control for management of western corn rootworms.

Joseph L. Spencer, Eli Levine, and David W. Onstad, Center for Economic Entomology; Michael E. Gray and Scott A. Isard, University of Illinois

Species Spotlight

Terrestrial Isopods

Susan Post

Underneath moist logs and decaying leaves live a multitude of creatures, several of which may be terrestrial isopods, commonly known as sowbugs, woodlice, pillbugs, and slaters. These creatures are elliptical in shape, have seven equal pairs of legs, and two pairs of antennae. Isopods are primitive crustaceans related to crayfish, crabs, and lobsters.

While most crustaceans must live in or very near water, the terrestrial isopods are the only large group of crustacea to become adapted for life on land. Like all members of the crustaceans, they breathe with gills, but these gills must stay moist to operate so the terrestrial isopods are condemned to a life in damp places, usually underneath something like decaying wood or leaves. While independent of the water, they must restrict their activities to times and places where humidity is relatively high, so they are nocturnal and seasonal (encountered more frequently in damp rather than dry weather). And to conserve water, they don't expel their waste through water-based urine, but directly into the air as ammonia.

A sowbug (*Trachelipus rathkei*) at left and a pillbug (*Armadillidium vulgare*) on right with inset showing pillbug rolled up in defense posture.

Photos by Ed Zaborski, INHS Center for Economic Entomology

To cope with the problems of terrestrial life, the terrestrial isopods have a thick, hard exoskeleton where each body segment is topped with an armorlike plate that overlaps the plate on the section beneath. When disturbed, many of these isopods can curl themselves into a ball; this protects the softer underparts and appendages from attack and desiccation. Pillbugs are the most successful at this activity, their common name referring to the fact that when curled up they resemble tiny pills.

Unable to return to the water to breed, female isopods must carry water around with them. Fertilized eggs are deposited in a water-filled marsupium or brood pouch, located beneath the thorax. When the eggs hatch, the young isopods, which resemble adults, must remain in the pouch until they can fend for themselves. They are soon liberated from the pouch, however, and after four or five molts they reach adulthood. Molting continues throughout their lives and is rather peculiar in the isopods. First, the posterior half of the skin is shed and then two or three days later the anterior half is shed, giving rise to bicolored individuals during the molting process.

The terrestrial isopods are omnivores and scavengers, feeding mainly on vegetable or animal matter. Their food is usually already dead and decaying in the leaf litter, in crevices, or under rocks, logs, and bark. They feed wherever plant and animal refuse and detritus accumulate and moisture is present.

Two common species that may be encountered in Illinois are *Trachelipus rathkei*, a sowbug, that is 5/8 of an inch long and smooth brown in color, and *Armadillidium vulgare*, a pillbug, which is the same size as the sowbug but dark gray or black with rows of distinct spots.

Teacher's Guide to "The Naturalist's Apprentice"

These activities need not be limited to summer. They can be done anytime, even in winter. In winter, the students can look for signs of animals in the snow. There is also no need to go to a natural area to observe nature. The school yard or a park should have plenty of life for students to discover. This activity works best if the students work individually or in pairs. Discourage larger groups. When students get back to the classroom, they should share their findings either by reading sections of their notes, or you could collect the journals and take excerpts from them to form an essay (chronicle, record) of the day's field trip.

Encourage the students to take notes of whatever they see and hear. This will be the beginning of keeping a nature journal or field notebook. They can use the notes they take and the sketches they make to try to identify what they saw once back in the classroom. Try to have reference books on trees, flowers, and other plants. Guides to animal tracks, soil life, forest life, prairies, or whatever types of habitats you visit would be helpful.

Recommended equipment: Each student should have a small notebook and a pencil for notes and sketches. A hand lens and a pair of forceps for each pair of students would also be very useful.

Precautions: Make sure you and the students are familiar with the appearance of poison ivy and stinging nettles. Also, be careful when turning over rocks and logs—snakes may be underneath them. Take precautions against insect bites and ticks.

The Naturalist's

Up Close and Personal

Carolyn Nixon

Up Close and Personal: Take a closer look at the world around you.

Summer is a great time to go out and observe nature. When you go into the woods, you can't help but notice the trees around you. When you walk into a prairie or old field, the grasses and flowers are the first thing you see, and the calling and displaying birds are difficult to overlook. However, there is much more to be seen than what first meets the eye. All you need to do is take a closer look. Here are a few exercises that will help you learn to observe the little things around you.

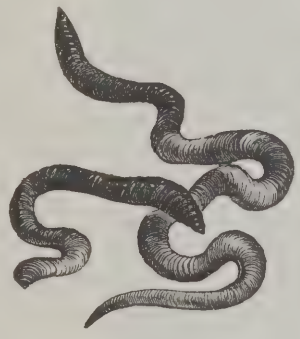
1. Take a notebook and pencil with you and write down your observations. You will find that keeping notes will make you look closer at your subject. You may find it helpful to make a sketch of your subject.

2. Whether you are visiting a forest, grassland, or wetland, slow down and take your time. You will see a lot of things that you will miss by running or even walking too fast.

3. Stand or sit in one spot for at least five minutes. Be very quiet. What is going on around you? Close your eyes. What do you hear?

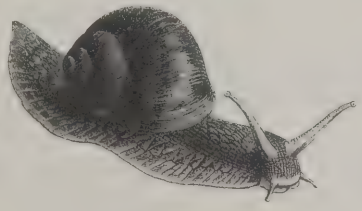
4. Observe a single plant. If it is in flower, use a hand lens to look at the flower. Are there any insects or spiders there? What are they doing? Also look at the leaves. Are there any insects present? Are there any spots, holes, or curled areas? Is the leaf smooth to the touch? Is it rough or hairy? Look at the stem or bark. What do you see and feel?

5. Find a rock or a piece of wood that is on the ground. Very carefully turn it over. What do you see underneath it? Do not pick up any life you find. Just observe it. How do the animals react to being exposed to the light? Carefully place the wood or rock back the way you found it.



6. Look closely at the ground. Is there any bare ground? Are there any animal tracks? If so, make a sketch of them. Is the ground littered with leaves or plant debris? What is it from? If there is plant litter, carefully lift up some of it. Is there any life underneath it? Look at the litter closely with a hand lens.

7. Find one plant that you can't identify and describe it in detail. Include sketches of the leaves and flowers, or any other distinguishing character. When you get back to home or school, look in books and try to identify the plant. You may need to go to the library and check books there.



ILLINOIS
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61820 USA

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INHS Reports is edited by Tom Rice and Charlie Warwick and printed on recycled and recyclable paper Design by Otto-Walker Communications

New Building

continued from front page

In addition to significant improvements in the quality and quantity of space, the new building is planned to include several specialized facilities that the Survey currently does not possess. These include a suite of large rooms and associated environmental rooms for aquatic research, and another suite of high-containment rooms that meet federal standards for working with exotic insects and pathogens transmitted by insects. And for the first time, we will have good facilities for our educational outreach program, including a 200-seat auditorium designed specifically for natural history presentations.

The amount of space dedicated to each major function is as follows:

- Research labs and research support space: 46,810 net square feet (nsf)
- Biological collections and associated workrooms: 21,370 nsf
- Offices for scientific staff: 21,155 nsf
- Offices and support space for administrative staff: 9,060 nsf
- Library: 8,800 nsf
- Graduate student offices: 6,000 nsf
- General storage for office and research materials: 4,570 nsf
- 200-seat auditorium: 3,000 nsf
- Several small meeting rooms: 2,055 nsf
- Miscellaneous other areas, including an entryway foyer, a teaching lab, and a lunch room: 2,285 nsf

This is a State of Illinois project managed by the Capital Development Board, with Teng and Associates, Inc., of Chicago as the architect/engineering firm. At this time Teng and Associates are in the design development stage of their work. Approximately 20% of the total funds needed for the project are in hand, and we expect to construct part of the building in the near future while we seek additional funds. The first phase will primarily house our biological collections, but all Survey programs will benefit by being able to expand into vacated space when the collections are moved.

This will be the first significant new construction for the Survey since the Natural Resources Studies Annex was constructed about 30 years ago and the first relocation of our headquarters since 1939. While buildings do not define our program, we are certain that this new research center will allow our Survey to better serve the people of Illinois.

W. Ruesink, Assistant Chief

ILLINOIS NATURAL HISTORY SURVEY

Reports

Autumn 2000
No. 365

INSIDE

Book by INHS Scientist Wins National Award

Stephen P. Havera, Director of the Forbes Biological Station of the Illinois Natural History Survey (INHS), was honored by the Wildlife Society as the recipient of its 2000 Wildlife Publications Award for the Outstanding Book Category for his comprehensive book on Illinois waterfowl.

The book, *Waterfowl of Illinois: Status and Management*, was published last year by INHS. The award was presented on September 13 during the Wildlife Society's 7th Annual Conference in Nashville, Tennessee.

The 672-page book and its companion field guide are based on more than a century of research. They capture the rich waterfowl tradition of the region and document the history, habitats, populations, harvest, nesting biology, management, banding, food habits, programs, and other information relevant to waterfowl and wetlands.

Havera has studied a variety of wildlife species in agricultural, forest, and wetland landscapes during his 30-year career with the Survey. He has been conducting studies at the Forbes Biological Station near Havana since 1978 and became director of that station in 1982. Havera, a native of Peoria, received a B.S. degree in Biology from Bradley University and a Masters in Zoology and a Doctorate in Ecology from the University of Illinois. He holds a faculty appointment at both universities.

Dr. Stephen P. Havera, Director of the INHS Forbes Biological Station. **Photo by University of Illinois Photo Services**

Havera is the fourth member of the Survey's Center for Wildlife Ecology to win the award. Previous winners were Harold C. Hanson in 1966 for *The Giant Canada Goose*, Frank C. Bellrose in 1976 for *Ducks, Geese and Swans of North America*, and Bellrose and Daniel J. Holm in 1994 for their book *Ecology and Management of the Wood Duck*.

Waterfowl of Illinois: Status and Management and the companion field guide, *Waterfowl of Illinois*, are available for $69.95. They can be purchased separately for $59.95 for just the book or $14.95 for the field guide.

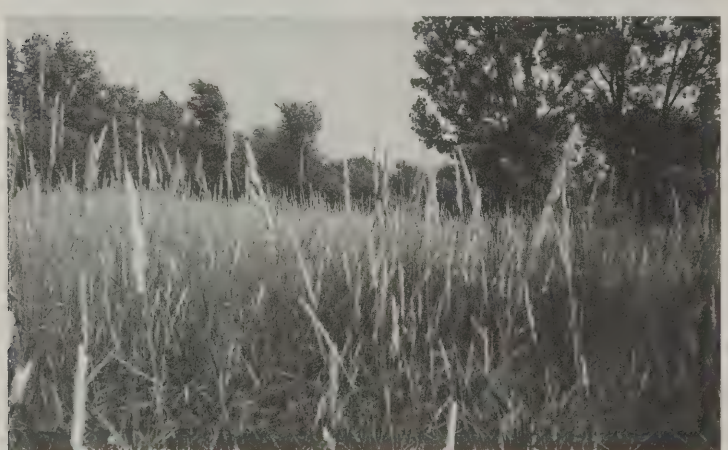
Ordering information is available by calling (309) 543-3950 or by visiting www.theramp.net/inhswaterfowl on the Web.

Exotic Vegetation in Illinois Wetlands

The loss of wetland habitat across the United States has been well publicized in recent years. Here in Illinois the losses have been particularly devastating, with well over 90% of our original wetland acreage already lost and the majority of the remaining substantially degraded. Surprisingly to many people, much of this degradation can be attributed, at least in part, to invasion by exotic plant species. As used here, the term "exotic" refers to any species not native to Illinois, either native to another country or to another part of the United States. With human activities), agricultural runoff, and alterations in wetland hydrology (e.g., changes in water depth, lack of water level fluctuation), hardy, disturbance-tolerant exotic plants often come to dominate. Although these invasive exotics often take advantage of disturbed conditions, this is not a requirement and many species readily spread into relatively undisturbed, high-quality, natural communities, displacing native plants. Community composition and diversity can be dramatically altered, often threatening or eliminating rare or endangered species.

Garlic mustard (*Alliaria petiolata*) is now a serious problem in forested wetlands of northeastern Illinois. **Photo by Michael Jeffords, INHS Center for Economic Entomology**

In an effort to quantify the prevalence of exotic plant species in Illinois wetlands, data from over 2,500 wetlands were analyzed, based principally on information collected from wetland delineation projects conducted throughout Illinois. In this analysis, only "dominant" plant species were considered. Dominant plant species are major components of the plant community, contributing more to the character of the community than other species present. Therefore, this discussion of exotics can be considered a fairly conservative survey of their impact because they are considered in this analysis only when they were very prevalent (dominant) in a given wetland community.



Reed canary grass (*Phalaris arundinacea*) is the most prevalent exotic wetland plant species in the northern half of Illinois. **Photo by Brian Wilm, INHS Center for Wildlife Ecology**

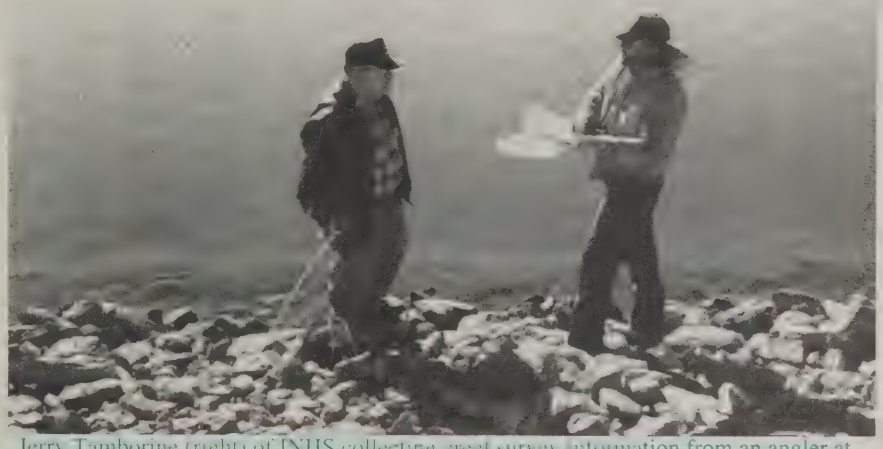
Seventy-seven plant species not native to Illinois were identified as dominant in wetlands throughout the state. Reed canary grass (*Phalaris arundinacea*), common in a variety of wetland habitats, was clearly the most prevalent species overall, occurring as a dominant in 30% of all wetlands and in 48% of the northeastern Illinois (Chicago area) wetlands. Narrow-leaf cattail (*Typha angustifolia*), primarily a pond and marsh species, was dominant in about 10% of all wetlands. Overall, 52% of all wetlands had at least one dominant, exotic species. In the Chicago region of northeastern Illinois, an amazing 76% of wetlands contained dominant exotic species, compared to only 37% for the rest of the state. Within the Chicago area, marshes and herbaceous wetlands (such as wet meadows and sedge meadows) showed the highest rates of exotic dominance, an alarming 81%, followed by forested wetlands, also very high at 71%. Buckthorn (*Rhamnus cathartica*) and garlic mustard (*Alliaria petiolata*), although not typically thought of as wetland species, were, unfortunately, common dominants in northeastern Illinois forested wetlands. Two nonwetland, non-native, lawn and pasture grasses, bluegrass (*Poa* spp.) and fescue (*Festuca* spp.), were fairly common wetland dominants around the state, as were two smartweeds (*Polygonum persicaria* and *P. hydropiper*), moneywort (*Lysimachia nummularia*), and curly dock (*Rumex crispus*). Purple loosestrife (*Lythrum salicaria*) was a common exotic dominant in Chicago area marshes.

Overall, levels of exotic species dominance are very troublesome, particularly in the Chicago region where prevalence is extremely high. Although more well-known, problematic exotics, such as purple loosestrife and garlic mustard, are a concern, reed canary grass appears to be the biggest threat to wetlands statewide. Forming dense stands capable of excluding virtually all other plant species, this perennial grass readily spreads into most wetland habitats and is already likely beyond control throughout much of Illinois.

Brian Wilm, Center for Wildlife Ecology

Database Management and Analysis of Fisheries in Illinois

One of the goals of fisheries management is to maintain healthy fish populations while providing recreational fishing opportunities for the public. To accomplish a variety of fisheries management goals requires continuous feedback on habitat, fish population structure and abundance, and the fisheries they support. The Illinois Natural History Survey (INHS) Center for Aquatic Ecology has been working with the Illinois Department of Natural Resources (IDNR) Division of Fisheries to collect, manage, and analyze a wealth of fisheries information. This project, entitled Database Management and Analysis of Fisheries in Illinois, is supported through funding by the Federal Aid in Sportfish Restoration Program, the IDNR Division of Fisheries, the University of Illinois, and the Illinois Natural History Survey.



Jerry Tamborine (right) of INHS collecting creel survey information from an angler at Clinton Lake (DeWitt Co., Illinois). **Photo by Betty Carroll, INHS Center for Aquatic Ecology**

A primary component of the project is to collect information on the fisheries of lakes and streams in Illinois. This information is collected through angler surveys, often referred to as creel surveys. The INHS conducts creel surveys on approximately 15 lakes and streams statewide each year. These surveys typically run from mid-March through October for most lakes, but can extend into the winter months on lakes with ice fishing or on power plant cooling lakes, which are typically open to fishing all year. Surveys are conducted by interviewing anglers and periodically counting the number of anglers fishing the body of water at any given time. INHS scientists use these data to make estimates of the fishing pressure and harvest of sport fish in each lake or stream surveyed. These estimates are used by managers to estimate fishing mortality, angler catch rates, and size distribution of caught fish, thereby providing data necessary for evaluating harvest regulations and determining other management objectives. Information collected from these creel surveys is vital to understanding the quality of each fishery.

Another important component of the project has been the development of a custom database software and analysis package, the Fishery Analysis System (FAS). This software is distributed to IDNR biologists statewide, who use it to enter and analyze the data collected from habitat and population surveys on Illinois streams and lakes. Estimation of stream index of biotic integrity and calculation of fish population size structure indices such as proportional stock density (PSD) are just a few of the important analytical tools contained in FAS. Additionally, FAS is used by INHS scientists to enter and analyze data collected from creel surveys. By combining many kinds of fisheries data into one common software package, FAS provides researchers and managers with the information necessary to manage, sustain, and improve the health of fisheries resources in Illinois lakes and streams.

Information contained in FAS is currently being used by project scientists to evaluate the effects of experimental harvest regulations on bluegill (*Lepomis macrochirus*). In 1999, IDNR imposed bag limit and length limit regulations for bluegill on several lakes in Illinois in an attempt to understand and correct for stunted growth. INHS conducted creel surveys on each of these study lakes prior to the experimental regulations, and researchers plan to return to survey these lakes in a few years to evaluate the effectiveness of the harvest regulations.

Recently, INHS scientists examined the relationship of population size structure and abundance indices with angler catch rates of largemouth bass (*Micropterus salmoides*). Preliminary results suggest that angler catch rates of catchable-sized largemouth bass in the spring can be estimated from PSD and catch-per-unit-effort (CPUE) estimates collected via electrofishing surveys in the previous fall. Using this information, IDNR fishery managers will be able to predict trends in any fishery and will be able to adjust stocking levels and harvest limits accordingly.

Darren M. Benjamin and David P. Philipp, Center for Aquatic Ecology

The Critical Trends Assessment Program: Gathering Data on the Condition of Illinois' Ecosystems

The Critical Trends Assessment Program (CTAP: dnr.state.il.us/orep/inrin/ctap/ctaphome.htm) was initiated in 1991 to assess the current condition, future trends, and extent of Illinois ecosystems. Decisions, including how to save, enhance, and restore our heritage for future generations, are the responsibility of all Illinois citizens and require tremendous amounts of reliable information. Much new information is being collected now and CTAP is working on how best to package and deliver it. In 1994, Phase I of CTAP ended with the publication of a seven-volume report summarizing existing information on Illinois ecosystems.

As a direct result of the lack of standardized information reported during Phase I, four distinct but complementary components of CTAP Phase II were initiated:

1. Land cover mapping (using satellite imagery and computer technology) of the entire state.
2. Establishment of a small, highly skilled team of professional scientists (at the INHS) and a larger network of dedicated, well-trained "citizen scientists."
3. Use of professional scientists (biologists, geologists, hydrologists) to accumulate existing data in the form of Watershed Assessment Reports.
4. The development of a Web-based information delivery system, the Illinois Natural Resources Information Network.

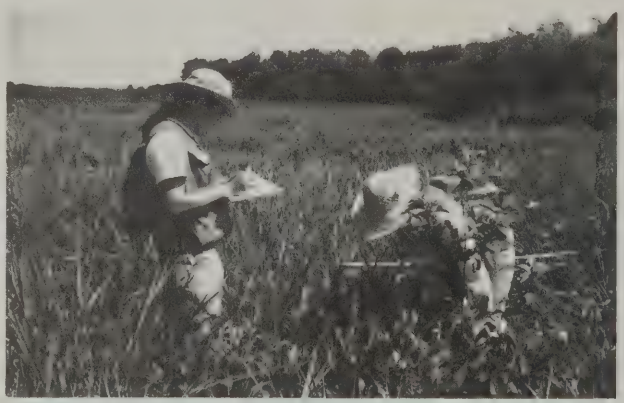
Indicators of Ecosystem Quality

The toughest initial question when starting any monitoring program is, What aspects of the ecosystem should be monitored? Professional and EcoWatch staff have settled on a number of biological assemblages and physical and chemical attributes as indicators of ecosystem condition. The EcoWatch parameters were determined with input from the professional scientists so that both monitoring efforts complemented each other.

Some Emerging Trends

Professional biologists have finished their fourth year of monitoring, while some aspects of citizen monitoring have been ongoing since 1995. Some statewide and regional trends are evident even with this small amount of new information.

Streams: Most streams in the state have been channelized and are now fed by a system of tiles. Additionally, the protective tree canopy of many streams has been removed, increasing water temperature and changing the food base from that of tree leaves to algae. These modifications have left an estimated 75% of all streams with a fair-to-poor habitat quality rating. Consequences of this are that native fish and macroinvertebrate species have less suitable habitat on which to live and forage. Poor habitat conditions have also led to few sensitive ephemeroptera, plechoptera, and trichopetera (EPT—insects with a wide range of sensitivity to disturbance) species remaining in the northern 75% of the state, where historical records substantiate their presence. Both the Hilsenhoff biotic index (HBI—measures general stream disturbance) and the macroinvertebrate biotic index (MBI—collected by CTAP citizen scientists) indicate that most streams were at least moderately impaired by organic enrichment and overall disturbance. Even sites with high EPT scores often have biotic index scores indicating disturbance. The fish community in many CTAP streams was dominated by just 2 or 3 fish species, sometimes by 1 or more of the 15 introduced species found in the state.



INHS CTAP scientists Jamie Ellis (left) and Connie Carroll monitoring plants in Clinton County. **Photo by Michelle Blyal**

Forests: Two hundred years ago, 38% of Illinois was forested. Today, 14% of the state's land area remains in forest. Forest cover is now slowly increasing, but the plant species composition of our oak- and hickory-dominated forests is changing due to the introduction of non-native species, habitat fragmentation, and fire suppression. The average CTAP site contained 58 native plant species, only three (5.2%) of which were introduced, but where introductions were present, they tended to crowd out native species. The shrub layer of forests was most dominated by introduced species. More than 70% of shrub stems counted by citizen scientists were of introduced species. Except for buckthorn and white mulberry, introduced trees were not a problem in the interior of most Illinois forests.

Grasslands: About 61% of the presettlement landscape of Illinois was prairie. Nearly 20% of the state is still characterized as grassland, although only 0.01% of the original prairie persists in a high-quality condition. CTAP sites contained an average of 20 plant species with 7.5 (37.5%) of them introduced. High-quality prairies have been demonstrated to support 100–140 different plant species. Of all terrestrial ecosystems, grasslands were the most heavily dominated by introduced species. Amazingly, 60 of 71 monitored sites had an introduced species as their most dominant (abundant, by percent coverage) plant. The major culprits in this takeover of grasslands were meadow fescue and Kentucky and Canadian blue grasses, all planted as forage or hay for livestock. On average, slightly less than two

Continued on back page

New Illinois Wilds Institute For Nature Course

Photographing Nature: The Natural History of the Cache River Wetlands

Come join photographers and biologists Dr. Michael R. Jeffords and Susan Post from the Illinois Natural History Survey and biologists from the Cypress Creek National Wildlife Refuge in a unique two-day course entitled "Photographing Nature: The Natural History of the Cache River Wetlands." Class is limited to 25 participants so register early!

WHERE: The course will occur in far southern Illinois in the Cache River watershed. Participants will stay at the Cheekwood Inn (Best Western), near Ullin, IL (Exit 18 on I-57). Classroom activities will be held at nearby Shawnee Community College.

WHEN: October 27–29, 2000. Participants should arrive at the Cheekwood Inn before 6 p.m. on October 27 to check in.

COURSE DESCRIPTION: The first classroom session on nature photography will be on Friday night from 7 to 10 p.m. at Shawnee Community College. Saturday will be spent in the field at various sites around the area—Heron Pond, Section 8 Woods, and Cypress Creek National Wildlife Refuge—photographing and learning about the area. A second classroom session on photography will be held at Shawnee Community College on Saturday evening from 7 to 10 p.m. An additional field trip will be arranged for Sunday morning to additional Cache River sites or to areas in the nearby Shawnee Hills. Fall color should be at its peak!
Classroom sessions will include all aspects of nature photography and an introduction to this unique and beautiful area. Both novice and accomplished photographers are welcome. We will carpool to the various field sites.

COST: Tuition for the course is $125.00 and includes all course materials, dinner on Saturday evening, two box lunches for Saturday and Sunday, and snacks. Breakfast on Saturday and Sunday is on your own (Cheeko's Restaurant adjoins the hotel). Lodging costs are not included in the tuition, but are very reasonable—double occupancy rooms are $22.00/person; single occupancy rooms are $44.00/person. Room arrangements can be made by IWIN staff.

Registrations accepted until October 15, or until course is full, so register early!

To register for this class or to obtain more information, call Susan Post at: 217-493-9959 or leave message on voice mail at 217-333-6659

Illinois Valley Ticks

During this past spring, INHS entomologist John Bouseman and INHS affiliate Dr. Jeffrey Nelson found blacklegged ticks, *Ixodes scapularis*, at sites in Fulton and Peoria counties. The investigators collected the ticks by dragging cloth flags at sites where people had previously reported that they had encountered "deer ticks" in the environment.

The blacklegged tick was reported from many of the Illinois Valley corridor counties in the late 1980s and early 1990s on the basis of the collection of ticks from deer at check stations in those counties during the fall firearm seasons. Thus, the tick was detected in Kankakee and Putnam counties in 1988; in Brown and Peoria counties in 1989; in Bureau, Grundy, LaSalle, Scott, Schuyler, and Will counties in 1990; and in Marshall and Tazewell counties in 1992.

In 1997, Bouseman and Nelson found significant numbers of the blacklegged tick in Grundy and Will counties, and it was determined that the ticks were infected with the causative agent of Lyme disease. As of this writing, it remains unknown whether or not the Fulton and Peoria county populations are infected with the Lyme disease spirochete.

It appears that blacklegged tick populations are increasing in the Illinois Valley, and those engaging in outdoor activities in the area should take precautions to avoid tick bite.

A female blacklegged ("deer") tick. Scale is in millimeters. **Photo from INHS image archives**

John K. Bouseman, Center for Economic Entomology, and Jeffrey A. Nelson, M.D., Rush Medical College, Chicago

Species Spotlight

Bald Cypress

Susan Post

Illinois isn't usually an area that comes to mind when cypress trees are mentioned, but swamp vegetation typical of the Southeastern Coastal Plain reaches its northern limit in extreme southern Illinois (Alexander, Pulaski, Johnson, and Massac counties). Long before human records were kept, this strip of southern Illinois bordered the shoreline of a much larger Gulf of Mexico. Though the seas have retreated, the coastal plain of Illinois still resembles the landscape that surrounds the present-day gulf.

A bald cypress in southern Illinois.
Photo by Michael Jeffords, INHS Center for Economic Entomology

The bald cypress, whose name comes from the tree's habit of shedding its needles, giving it a bald appearance, has always elicited comments from those who view it. An English journalist in the 1860s described them as "a forest of dead trees, their ghostly leafless arms over buried trunks like plumes over a hearse. . . ." While making a botanical reconnaissance of several southern Illinois counties in 1919 for the Arnold Arboretum at Harvard, Earnest Palmer described bald cypress: "One of the most remarkable and quite the most conspicuous of the southern trees of this region is the cypress (*Taxodiurn distichurn*). . . . Specimens from one hundred to one hundred and fifty feet high and measuring from four to six feet in diameter above the swelled base were by no means rare. . . ."

Bald cypress trees are not true cypresses but belong to the same plant family as the sequoias, Taxodiaceae. These trees are the sequoias of the Midwest, with some reaching over 100 feet tall and from 800 to 1,500 years of age. The oldest and largest tree in the state is a bald cypress.

Needles appear in late March or early April with male and female flowers produced separately on the same tree. Male flowers are produced in purple clusters at the end of the preceding year's shoots. Small rounded female flowers are also borne on the preceding year's branchlets and may be found singly or in groups. The small (1.25 inches in diameter) fleshy purple cones ripen during October. The sticky seeds are scattered by water and require exposed mineral soil for germination. Once germinated, a seedling must not be inundated for more than three weeks during its first year.

These swamp trees have swollen bases (buttresses) and knees and can reach giant proportions. The cypress buttress, a flairing of the lower trunk, develops in response to water and helps provide a firm footing in the swamp. Knees are distinguished by their smooth conical shape and are produced on land that is subject to alternate flooding and drying. The height of a cypress knee usually corresponds to the high-water mark in the swamp.

With the exception of the chestnut, the bald cypress has probably had the greatest reduction in volume over the past century of any American tree. Bald cypress was once in great demand for shingles, shakes, and posts, anywhere wood is used in contact with the soil and exposed to weather because the wood is resistant to rot.

Perhaps the best place to view a bald cypress forest (swamp) is Heron Pond Nature Preserve near Vienna, Illinois. Here bald cypress, with its lush, feathery foliage, engulfs you. For a time you can be transported into the world of the 1860 journalist or the 1919 botanist Earnest Palmer and get a unique view of an Illinois treasure.

Teacher's Guide to "The Naturalist's Apprentice"

Notes for teachers and parents

Using forceps or tweezers may be helpful when picking up and moving the leaf.

When selecting rubber stamp pads, be sure to purchase the nontoxic ones. Have a variety of colors of ink pads available. More than one color of ink can be used on a leaf. The multicolored ink pads give beautiful results. Leaf prints can also be made using watercolor paint with a wide brush. Students could make art prints to hang on the wall or nature notecards.

Many rubber-stamping products are available in craft stores for producing special effects. For example, you can stamp with a pigment-based pad and emboss the image with embossing powder.

Students could make a leaf print collection, identifying several trees from an area such as the schoolyard.

After some practice, students (or adults!) could make their own nature print T-shirts by using fabric paint instead of ink.

Making Leaf Prints

Carolyn Nixon

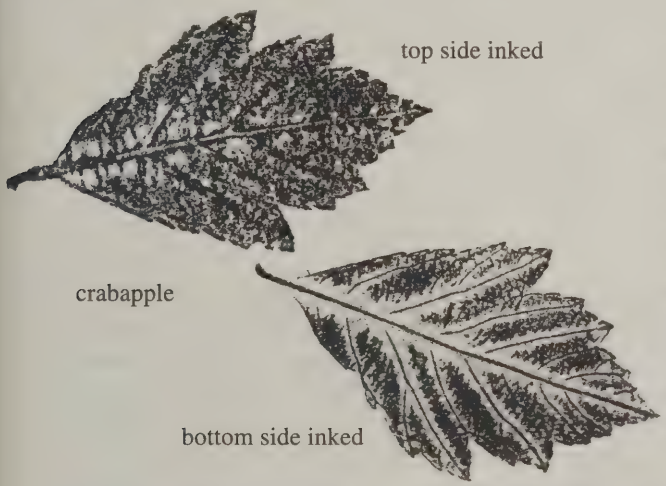
Making Leaf Prints

It is traditional to collect leaves in the fall and press them between pages of a book until they have dried. Although they can last a long time, the leaves quickly turn brown and become brittle. Instead of saving the leaves, try "collecting" colorful images of them by making leaf prints.

shadbush

Collect leaves from a woods, field, or yard. You can use any kind. Leaves from flowers, herbs, or even weeds work just as well as tree leaves! It is helpful to press the leaves temporarily in a book or plant press as you collect them so they don't become damaged before you get them back to the work area.

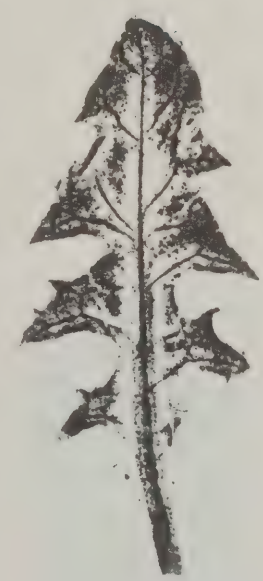
Before you begin to make the leaf prints, be sure to protect the work area with paper. Select a rubber stamp pad and place the leaf on the inked surface, with the top side up. Place a piece of paper over the leaf and rub gently across it, pressing the leaf against the ink. If the leaf is larger than the stamp pad, you will have to pick it up and shift it over. Repeat the procedure until the entire surface is inked. Then pick the leaf up by the petiole (leaf stem) and place it inked-side-down on the piece of paper you want to imprint. Place a second piece of paper over the leaf and rub gently across it with your fingers. Be careful not to let the leaf slide or the image will smear. Carefully lift the top piece of paper and then the leaf. The bottom sheet of paper should have a colorful image of the leaf.



top side inked

crabapple

bottom side inked



dandelion

Print some leaves by inking the top of the leaf instead of the bottom, and compare them. The veins of most plants tend to show up better if you use the bottom of the leaf.

Identify the plant that the leaf came from and write its name on the sheet of paper with the print. You can use prints to make your own field guide to the plants of the area where you collected the leaves.

Use leaf prints in a nature journal. With some practice you may be able to make leaf imprints without removing the leaf from the plant. Take a rubber stamp pad outside with you, place it under the leaf, press the leaf into the ink, and then onto the journal paper.

spurge

sweet gum

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CTAP

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grassland-dependent bird species were encountered in CTAP grasslands. High-quality prairies have been shown to support 6–12 nesting species. Except for the Eastern Meadowlark, Brown-headed Cowbirds (a nest parasite of other birds) were detected more often than any grassland-dependent bird species.

Wetlands: During presettlement times approximately 23% of the state supported wetlands. Today, that number is 3.2% and still declining. Of the remaining wetlands, few remain in high-quality condition. Most are severely degraded due to introduced species invasion, siltation, changes in hydrology, runoff of roadway deicing salts, drainage activities, and grazing. CTAP wetland sites contained an average of 15 plant species, only 2 (13.3%) of them introduced. However, as with grasslands, when sites contained introduced species, they were usually dominated by them. Reed canary grass, the most commonly encountered introduced species, often completely dominated a site, replacing most native species and forming a near monoculture. It was the dominant species at 22 of 78 monitoring sites. Some sites were still diverse and contained a high proportion of native species. Southern Illinois wetlands, in particular, seem to be the least affected by introduced species. The number of wetland-dependent bird species found at the typical site was 1.3 species on average, whereas high-quality wetlands usually support 6–10 wetland-dependent species.

Enough data have been amassed to support the contention that the health of the state's ecosystems is not particularly good. Streams have been drastically affected by decline in habitat quality and heterogeneity, while terrestrial systems are in a pitched battle with introduced and invasive species. Habitat fragmentation has also been problematic, the results of which are exemplified by loss of habitat- and area-dependent bird species. Even in the aquatic setting, habitat fragmentation poses the question of whether our streams will ever again support a diverse fauna, owing to the distance sensitive species must traverse from relatively isolated patches of high-quality habitat.

Readers can look forward to a thematic issue of *INHS Reports* in 2001 where CTAP professional scientists will present in much greater detail the results of Illinois' first statewide effort to determine current ecosystem conditions.

R. Edward DeWalt, INHS CTAP Group

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